INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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Make a Work-Done Inventory Covering 1924—

Check Up on Yourself, Your Plans and the Results That You Aimed at During the Past Year

THE beginning of a new year is a good time to sit down in some quiet place and make a list of our mistakes, disappointments and failures to accomplish the things we thought we were going to do during 1924. Such a frank analysis of ourselves and our work will point out the reasons for not being as far ahead in our plans as we thought we would be at this time, and in most cases show that the reasons therefor lie at our own doorstep.

Here are some questions that you should be able to answer:

1—Did you write out a plan and detail the things that you planned to do during 1924?

2—If so, can you show that the things accomplished will lead to greater results this year?

3—Have you analyzed the weak spots in your 1924 plan and know where and how to revise them so as to get the results you know are possible?

4—Are you making your plans known to your fellow-associates and getting their co-operation and enthusiastic support?

5—Is your lost-time (delay time) production less than last year?

6—Is there less or more equipment in the shop for repairs at this moment than there was last year, and is this due to better application and maintenance on the part of the organization that you control?

7—Have you investigated new and better methods for installing, repairing and maintaining your equipment? The world does not stand still—why should you?

8—Are plant operations any more efficient due to your efforts?

9—Did you save anything for the plant last year? If so, do you know how much?

10—Are your men happier and more interested in their work than formerly? Have you realized that it is your job to bring about this state of affairs?

11—Have you had to fire less men during 1924 than in 1923? If so, was it through improved methods that you devised for handling work or in selecting the men?

12—Have you made "the old man" feel that you are indispensable to his organization and one who can not be replaced very quickly?

13—Are you studying the work and results of other men holding positions like your own?

14—Have you asked INDUSTRIAL ENGINEER to help you get the information you need but find hard to locate when working out your problems? This is one good place to go when checking up on the practical ways that others have adopted to get their results.

Your answers to these questions will give you a real analysis of yourself and your work. If you adopt the practice of making a plan and then working that plan, your boss would be interested in a report embodying these questions, or similar ones, and their answers. Try it out.

Practical Pete

Three Large Manufacturing Units Created by Growth of the Electrical Industry

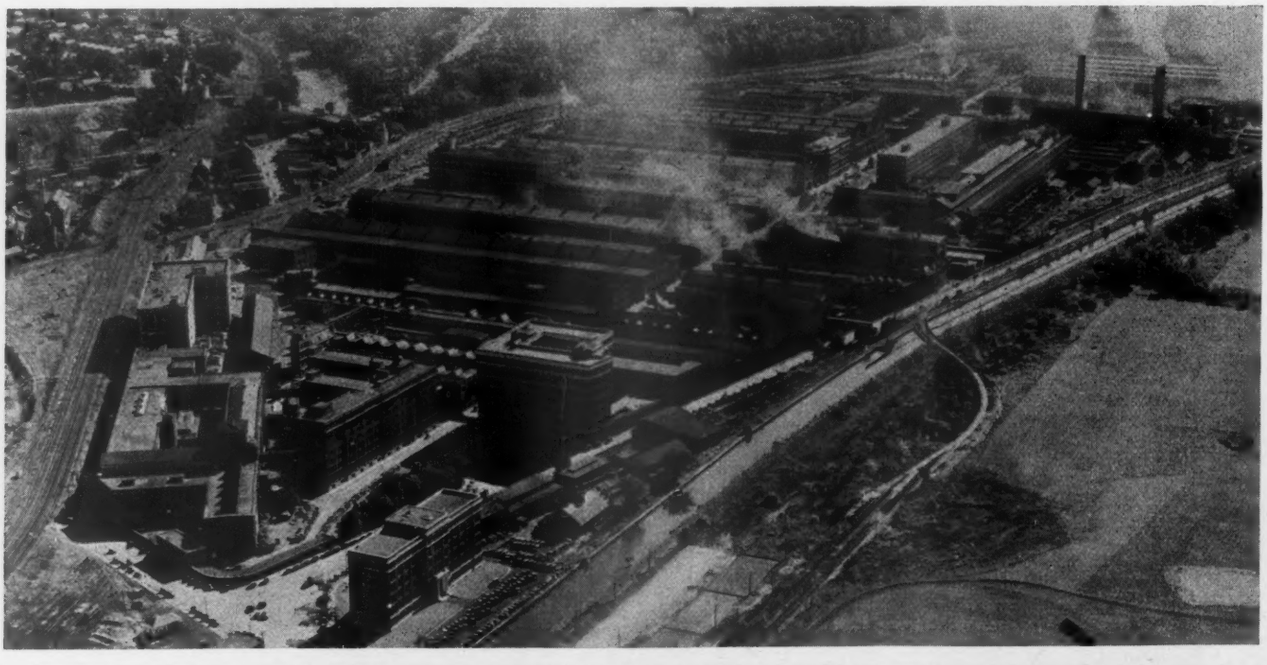
General Electric Company Allis-Chalmers Manufacturing Company
Westinghouse Electric and Manufacturing Company

These companies have been not only pioneers but continue to be leaders in the growth and development of equipment and methods for the generation and utilization of electricity in its multitude of commercial and industrial applications.

ELECTRICITY and its application have perhaps more than any other one thing been responsible for advancements made both commercially, industrially and scientifically in the past 50 years. Also, electric lighting is one of the few commodities which has shown a gradual reduction in cost from the beginning. Through improved methods of generation, transmission and utilization, the cost of a given amount of light is today only 5 per cent of its cost in 1880. It is largely through this reduction in cost that electric service is so extensively used in providing conveniences for the home, which have become necessities, and in the application of power and light in all lines of industry. The field, however, still has much room for development when it is considered that in the United States only 65 per cent of the manufacturing establishments and mines are electrically operated and only 38 per cent of the people live in electrically lighted homes. Additional applications of electricity to both home and factory are continually being developed. The extensive use of the radio is one of the most recent developments.

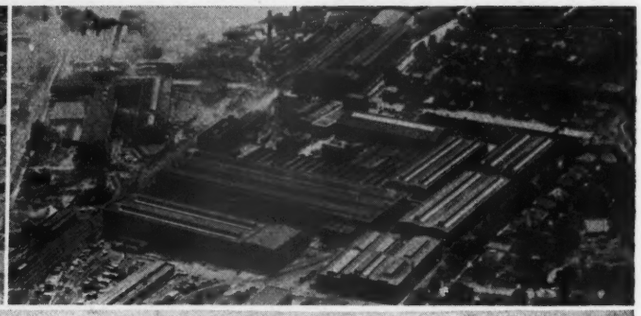
The broad application of electricity really dates from Sept. 4, 1882, when the first central station (the famous Pearl Street Station in New York City) was opened. Previous to this, electricity was in its experimental stages and at that time the telegraph was the only practical and established application. Electroplating was being done, however, and the telephone was in its infancy. Dynamos and electric lamps of various kinds had been invented but were not used commercially. This first commercial application, however, was quickly followed by numerous developments in many of the other types of equipment, such as motors, meters and numerous other kinds of equipment which are now common, everyday instruments. Many of these developments and inventions, which have brought electrical application up to its present high standing, have been recorded in the frontispiece pages of INDUSTRIAL ENGINEER during 1922.

In this development, the growth in the business of the General Electric Company, Schenectady, N. Y., Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., and Allis-Chalmers Company, Milwaukee, Wis., has closely followed expansion



An airplane view of the main office and works of the General Electric Company at Schenectady, N. Y.

The research laboratories of the General Electric Company are located here and all development work on new equipment is carried on at this plant until the designs are ready to go into quantity production when they are sent to some other plant of the General Electric Company. However, large turbine sets, large motors and generators, wire and cable and much of the equipment which is of a special nature is manufactured here. This plant covers a ground area of 523 acres and has a building floor space of over 6,000,000 sq. ft.; it employs approximately 25,000 workers. A multitude of industrial processes are carried on in this plant, as practically every kind of material is used in some manufactured product.



Three of the several plants of the General Electric Company.

Equipment which is produced on a quantity basis is manufactured in these or some of the other plants scattered over the country. At Erie, Pa., Works (above) electric locomotives, railway motors, reciprocating air compressors, crane motors, turbine sets and other large equipment is manufactured. The Pittsfield, Mass., Works (upper right) manufactures transformers, lightning arresters, electric fans, induction motors, industrial heating devices and other equipment. The Lynn, Mass., Works (right) produces meters and instruments, transformers, small turbine sets (up to 7,500 kw.), textolite and fabroil gears and a variety of other equipment. These three plants occupy over 800 acres, have 8,000,000 sq. ft. of floor space, and give work to about 22,000 employees. The various Lamp Works occupy about 6,000,000 sq. ft. of floor space and have around 12,000 employees. The total manufacturing area of all the plants is around 25,000,000 sq. ft. of floor space.

in the production of electricity and its utilization.

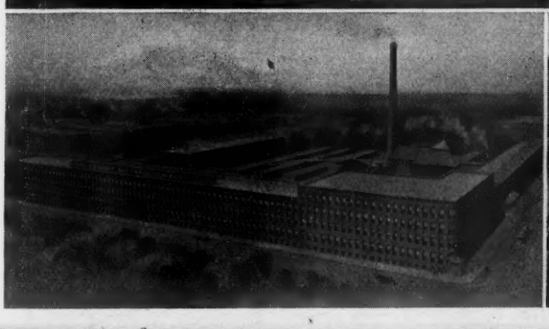
The General Electric Company was incorporated in 1892 and formed by uniting the Edison General Electric Company, the Thomson-Houston Electric Company and the Thomson-Houston International Electric Company. Because of the divergent ideas and methods employed by a number of individuals and organizations scattered all over the country, no great stride had been made up to that time in unifying electrical standards of generation, transmission and utilization which were so necessary to make the growth of the industry and its application universal.

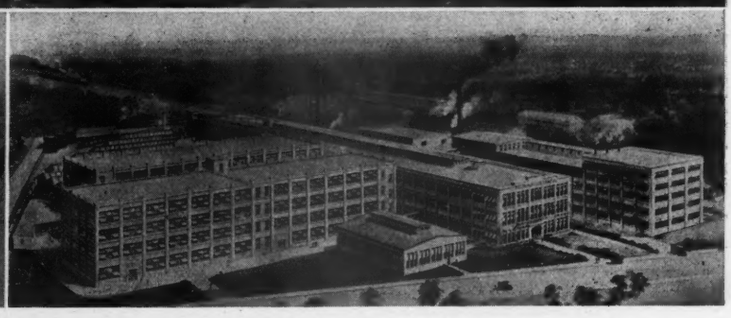
From a comparatively small beginning, this organization has grown until it is today the largest concern in the world devoted to the manufacture of electrical equipment. It has important manufacturing plants located at Schenectady, N. Y., Lynn and Pittsfield, Mass., Harrison, Bloomfield and Newark, N. J., Erie and Philadelphia, Pa., Fort Wayne, Ind., Cleveland, Ohio, Bridgeport, Conn., and lesser plants at many other points. The total land area of these plants is 2,050 acres; the total floor space of the buildings covers approximately 25,337,000 sq. ft. Over 75,000 persons are in the employ of the company.

Such extensive work, ranging

Three of the plants of the Westinghouse Electric and Manufacturing Company.

The main office and largest of the plants is located at East Pittsburgh, Pa., and contains more than 100 acres of manufacturing and floor space. In this plant the longest shop aisle is 70 ft. wide by 1,610 ft. long. Some 26 boilers with a total capacity of 28,000 hp. supply steam for heating the works and for driving Westinghouse turbo-generators which supply light and power. At the Bridgeport, Conn., Works (lower left) of the Bryant Electric Company over 500,000 sq. ft. of floor space are devoted to the manufacture of switches and electric wiring devices. The Bloomfield, N. J., (lower right) Works is one of the plants of the Westinghouse Lamp Company.





The main plant and general offices of the Allis-Chalmers Manufacturing Company.

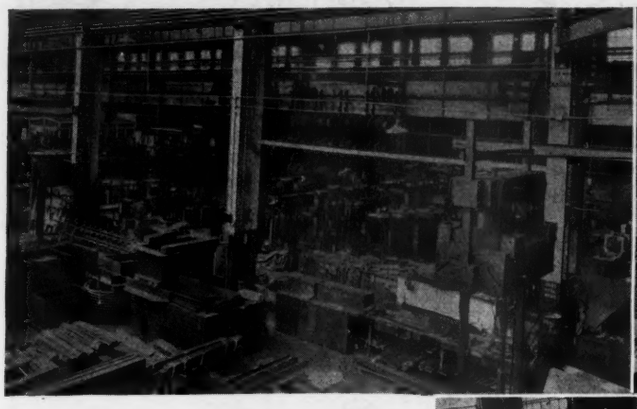
This factory is located at West Allis, a suburb of Milwaukee, Wis. Here the company manufactures a wide line of special heavy machinery for mining and metallurgical work and for cement, flour and saw mills, besides pumps, steam turbines, gas, oil, and steam engines, hydraulic turbines and a wide line of generating equipment, as well as motors for driving this machinery. In addition another factory, the Bullock Works at East Norwood, Ohio, a suburb of Cincinnati, is devoted to the manufacture of lines of smaller motors and other electrical machinery.

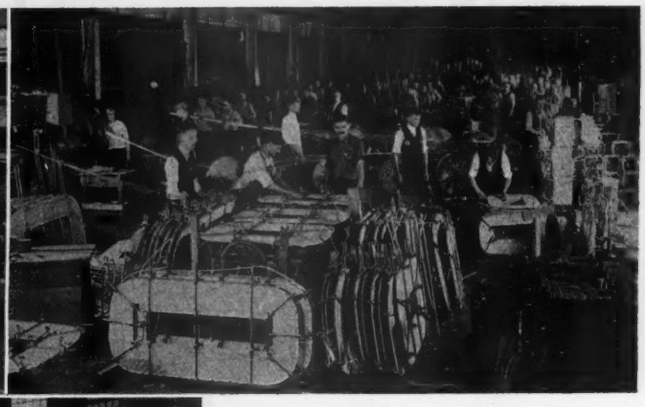
from the largest generating unit to the small pieces of apparatus, utilizes practically every known art, science and production method, including glass making, rubber working, casting, machining and forming of a large variety of metals, in fact practically all materials and kinds of refining processes are involved. Some of the work done in these plants is shown in the illustrations accompanying this article. In all, more than 500 different types of apparatus are produced, comprising electrical equipment for practically every class of industrial power application, lighting, mining, railways, central station systems and many others. The requisite standards of production and quality are maintained by adequate tests and a large research testing and standardizing laboratory.

About forty years ago, May 20, 1884, George Westinghouse began the manufacture of a new self-regulating dynamo for lighting service which had been invented by William Stanley, a young engineer. Up to that time Mr. Westinghouse had been manufacturing his invention, the air-brake, which is still used in train service, high-speed engines to

Departments devoted to the erection of heavy equipment at plants of the three companies mentioned below.

The illustration at the left shows a part of a manufacturing floor of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, Pa. After testing, the machines are placed on cars for the shipment to the consumer. The erecting floor of the Allis-Chalmers plant (lower left) shows one 10,000-kw., two 12,500-kw. and one 20,000-kw. turbo-generator sets in process of erection and test. The illustration at the right shows one bay of building No. 60 of the General Electric Company at Schenectady, N. Y., where steam turbo-generators ranging from 2,500 to 50,000 kw. in capacity are assembled and tested.





Some of the manufacturing operations performed by the three companies.

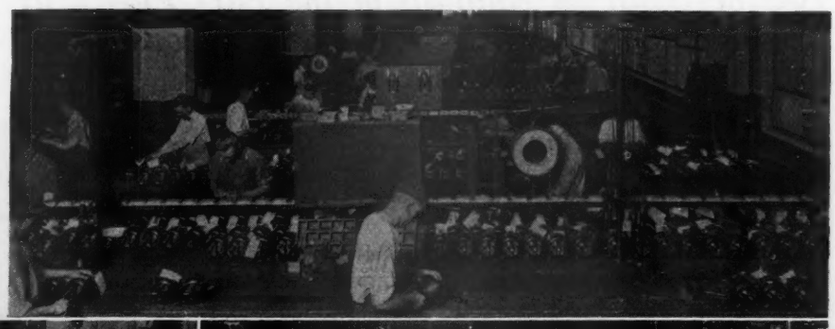
The illustration above shows the transformer assembly department at the Pittsfield, Mass., Works of the General Electric Company. Some of the operations incidental to the winding of the coils for transformers at the East Pittsburgh plant of the Westinghouse Company are shown in the upper right illustration. The illustration at the right shows a complete assembly of the rotor and main bearing for one Niagara Falls, 65,000-kva., 107-r.p.m. waterwheel generator in a bomb-proof pit for overspeed test at the Allis-Chalmers plant.

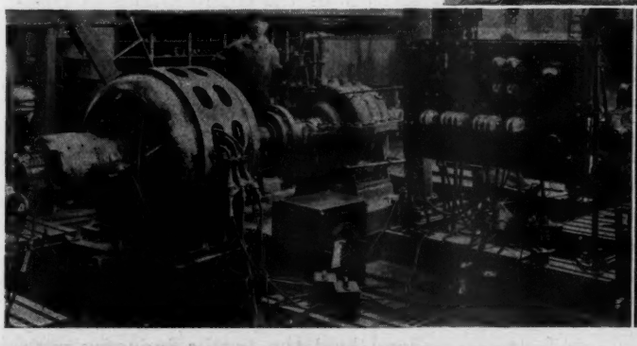
drive dynamos for arc lighting, and also controlled the Union Switch and Signal Company. At that time there was a big difference of opinion on the merits of direct and alternating current. Mr. Westinghouse favored alternating current and led in the development of a transformer to "reduce the pressure," a meter to measure the alternating current used, and a motor which could be used to do useful work. Perhaps the two outstanding early commercial installations were: the lighting of the World's Columbian Exposition in 1893 and machinery for the first hydro-electric development at Niagara Falls in 1895. The company has been a pioneer in many of the electrical developments made since. From a small factory in 1886 with 200 men on the payroll, the demands of the Westinghouse Electric and Manufacturing Company have increased until now it occupies 23 plants, many of which are devoted to the production of one class of electrical product, such as motors, lamps, fittings or other equipment. Approximately 50,000 men are now employed.

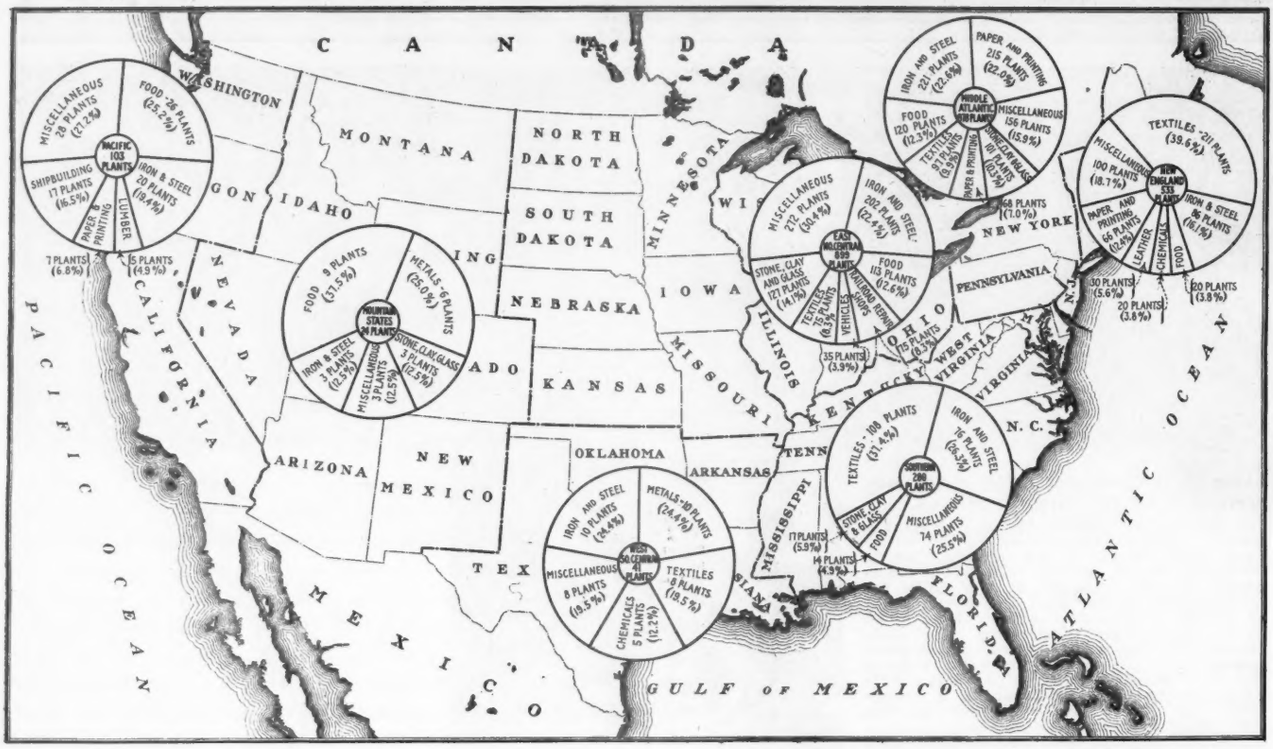
Development and research work is carried on at the main plant at East Pittsburgh, Pa. Other plants are located at Bridgeport, Conn., Cleveland, Ohio, Newark, N. J., Bloomfield, N. J., and other centers. In addition to electrical products, the company through its associated companies, manufactures air-brakes, stokers, water, gas and air meters, industrial and railway gearing, flexible *(Continued on page 46)*

Three other examples of the many operations required in the manufacture of electrical equipment.

The illustration below shows a shop test of a 6-in., 4-stage Allis-Chalmers centrifugal pumping unit direct-connected through a magnetic clutch to a 225-kva. synchronous motor. The pump has a rating of 900 g. p. m. under a head of 310 ft. at 1,000 r. p. m. The illustration at the right shows the testing department for fractional-horsepower motors at the Fort Wayne, Ind., Works of the General Electric Company. A part of the large-motor winding department at the East Pittsburgh plant of the Westinghouse Electric and Manufacturing Company is shown in the lower right-hand illustration.







This map shows the distribution of industrial plants in the United States using over 1,000,000 kw.-hr. of energy annually. This distribution of plants is based on an industrial survey conducted by the McGraw-Hill Co., Inc., and summarized on page 9.

Some of the Reasons for the

Growth of Well-Known Industrial Centers

Together with an Analysis of the Part Played by Available Sources of Power in Its Various Forms and Other Controlling Factors

By FRANK E. GOODING
Associate Editor, Industrial Engineer

THE main factors affecting the location of an industry include the source of raw material, market, labor supply and cost or availability of power. In the early days of American industry steam engines were expensive and not widely used. Therefore, available water power was one of the most important considerations and so a large number of the industrial centers in New England were built up around falls in small streams and rivers. This power had to be used where it was, since there was no means of transmitting it any distance. Incidentally, the measure of power used at that time was based on the number of spindles which the stream would operate satisfactorily.

The wider introduction of steam engines made the location of an industry more flexible, but to a certain extent this was dependent upon the supply of wood, and later upon coal, for fuel. Today, the facility with which electrical energy may be generated and transmitted hundreds of miles has enabled many industrial plants to take advantage of water power generated in the mountains (particularly in the West), where it would now be uneconomical to locate a plant. In other cases, water is used to generate power where it would be practically impossible to obtain coal for fuel. This is particularly true in some paper mill districts.

Today the expansion of certain well-established American industries and the development of facilities for the generation, transmission and application of power are going ahead hand-in-hand. Which is the cause and which the result may be a question for argument. A brief survey of the tendencies in the concentration of industry and the reasons therefor, is presented in what follows.

Industry in the United States may be considered as beginning in 1790, with the establishment of the first cotton mill, the Slater Mill at Pawtucket, R. I. Tanning of hides and production of lumber had been carried on before, but as more of a rough utilization of the natural resources of the country than as manufacturing industries. The invention of the cotton gin, which provided an adequate supply of cotton free from seed, gave considerable impetus to the cotton industry. Most of the market and labor supply, as well as available water power to drive the mills was located in New England. It was but natural that this industry developed in that part of the country.

With this early start, New England held the textile industry without much competition until about twenty years ago. Since then the

Carolinas have rapidly forged to the front as producers of cotton goods. Some of the reasons for this have been the short distance from the Carolinas to the cotton supply, the availability of an adequate supply of labor and water power or cheap coal. There have been a number of other interesting shifts of industry from one location to another, some of which will be brought out later.

The first big impetus was given to expansion of industry by the early railroad construction. By 1848 railroads were running out of Chicago and by 1867 they had been extended on to the Pacific Coast. As the West opened up the railroads made new markets for industrial plants in the East. While a part of the market was moving west, raw materials, labor and power were still concentrated in the East. However, with the development of the moldboard plow, the reaper and self-binder, the United States, particularly that part west of the Alleghanies, became an agricultural country. Previous to this, the farmer could raise but little more than he needed for his family, because he could not take care of it, and so had but little left over to feed those engaged in industry. Agricultural machinery enabled him to raise, care for and harvest several times his own needs. Thus, with their food supply assured, industrial workers could concentrate in larger communities and devote their whole attention to industry. Soon after the Central West became populated, industries began to spring up here and there through the territory to supply the agricultural districts of the cities built up around them. It was necessary to use steam engines for power, as there were practically no water falls in the central section of the United States.

Value of Products Produced Annually in Fourteen Prominent Industrial Centers

CHICAGO DISTRICT—$5,000,000,000—Steel and steel products, slaughtering and meat packing, foundry and machine shops, printing and publishing, men's clothing, railroad cars and a very widely diversified line of miscellaneous industries.

DETROIT, MICH.—$2,000,000,000—Automobiles and automotive products and diversified manufacturing.

PITTSBURGH, PA.—$1,429,287,000—Steel, rails, pipe and tubing, tin plate, and steel products, pig iron, crucible steel, coke, glass, machine shop and foundry products.

JERSEY CITY, N. J.—$969,537,000—Meat packing, petroleum refining and diversified manufacturing.

NIAGARA FALLS, N. Y.—$900,000,000—Electro-chemical industries.

KANSAS CITY, MO.—$590,192,000—Flour and grist mills, meat slaughtering and packing, agricultural supplies.

BIRMINGHAM, ALA.—$550,000,000—Steel and iron, cast iron pipe, cement, brick and clay products.

CINCINNATI, OHIO—$500,000,000—Slaughtering and meat packing, foundry and machine shop products, men's clothing, boots and shoes.

MINNEAPOLIS, MINN.—$500,000,000—Flour milling and diversified manufacturing.

NEW ORLEANS, LA.—$315,000,000—Cotton and cottonseed products, sugar, and diversified manufacturing.

DALLAS, TEXAS—$145,000,000—Shoes and leather goods, cottonseed oil and byproducts, cotton ginning and milling machinery and diversified products.

ATLANTA, GA.—$130,000,000—Diversified lines of manufacturing particularly for cotton ginning and milling machinery.

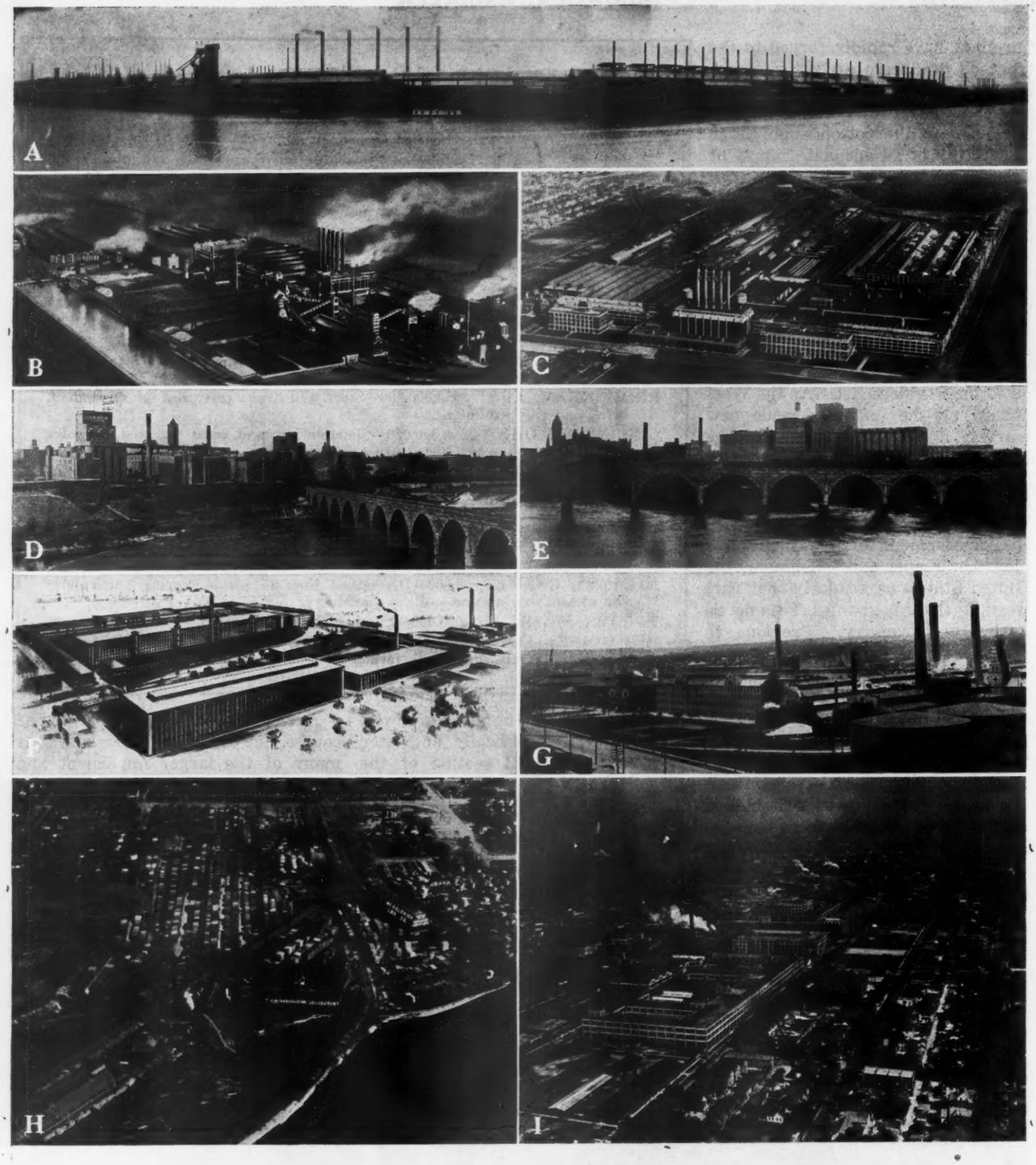
TACOMA, WASH.—$125,000,000—Lumber and furniture.

DES MOINES, IA.—$80,000,000—Meat packing, milling and diversified manufacturing, largely supplies to farmers.

The name of Akron, Ohio, is always associated with rubber tires and other rubber goods.

This view shows the two main plants of The Goodyear Tire and Rubber Co. at Akron, Ohio. A branch was built at Los Angeles, Calif., a few years ago. The rubber industry is of comparatively recent growth and it almost parallels the development of the automobile industry. The Goodrich, Firestone, Miller and other large rubber plants are also located in Akron.

Agricultural implements were, of course, one of the big needs and thus many of the larger implement and wagon factories were built up in the Central West, such as the International Harvester Company, Studebaker Bros.' Wagon Works (now the Studebaker Corporation), John Deere Plow Company, Moline Plow Company, J. I. Case Threshing Machine Company and others. With the prestige obtained in implement work, many of these have added the manufacture of automobiles or



Typical Plants Identified with Industrial Centers

A—Pittsburgh, Pa., has long been known as the "Steel City" and owes much of its growth to its favorable location at the junction of two rivers which give it a 40-mile water front and also to its closeness to the Pennsylvania coal fields and coke ovens. Illustration *A* shows the National Works of the National Tube Co., at Pittsburgh, Pa. Beginning at the left the different plants represent the steel works, blast furnaces, coal hoist, skelp mills, electric department, lap weld department, and butt weld department.

B and **C**—On June 4, 1924, Ford produced the ten-millionth car. These illustrations show the two main factories, *B*, the River Rouge Plant and, *C*, the Highland Park Plant. The Highland Park Plant occupies 278 acres of which 105 are under roof, and employs 65,000 workers. At River Rouge, with a plant area of 1,100 acres, the company operates the largest foundry in the world as well as a blast furnace, coke ovens, cement plant, machine shops, body plant, saw mill, paper mill, locomotive repair shop and a tractor plant, and has about 40,000 employees.

D and **E**—The first flour mill, at St. Anthony Falls on the Mississippi River, was established in 1822. Today the several flour mills grouped around these Falls at Minneapolis and St. Paul, Minn., are capable of producing 90,000 bbl. of flour daily. Illustration *D* shows the mills on the west bank, with the Washburn-Crosby plant in the foreground. Illustration *E* is of the Pillsbury plant, the largest mill in the world, and elevators on the east bank of the river.

F—Textile mills represent one of our largest industries and users of power. The cotton goods industry has a total of 1,863,542 primary horsepower and the silk, woolen and worsted industries have an additional total of 684,412 primary horsepower, all of which is about half electrified. This picture represents the cotton department of the Pacific Mills, a large textile organization with four plants at Lawrence, Mass. This one plant operates 184,096 spindles and 3,811 cotton looms.

G—Today, manufacture of machine tools is one of the important industries of Cincinnati, Ohio. Another important industrial development in this city is The Procter and Gamble Company Works, manufacturing soaps and many other products.

H—Lumber and lumber products are one of the important industries in the Northwest. About 40 of these plants are located in Spokane, Wash. One of the largest of these is the McGoldrick Manufacturing Co., which produces lumber and building supplies. Spokane is also surrounded by a large apple, grain and livestock center in addition to the timber areas.

I—Another important industrial plant of Detroit, Mich., is that of the Packard Motor Car Co. This plant, shown in the foreground, is one mile long. Several other large industrial works may be seen in the distance.

trucks in the development of the industrial Middle West.

The invention of the Bessemer process of steel making and its introduction in the United States in about 1861 built up a big industrial center in the Pennsylvania coal region where the coal is made into coke and also used for power. The iron and steel industry was perhaps the first big user of power and created a demand for larger, more powerful and better engines. This industry has ever since taken an important part in the development of better power-generating equipment and heavy electrical drives for its utilization. In but few other industries is a continuous uninterrupted supply of power so essential.

More recently, two other steel-making centers have been built up, due partially to the finding of a better supply of ore closer to these centers and also their nearness to market. For example, the Chicago steel district at the southern end of Lake Michigan is close to the Central Western market. Also the iron ore can be hauled to it almost entirely by boat, which is the most economical method of transportation. Although it is somewhat farther than the Pennsylvania region from the coking-coal fields, it is cheaper to haul the coal the longer distance than the finished steel because coal, being a bulk product, has a very low freight rate, particularly when compared to finished steel shapes. The other iron-producing region is in the vicinity of Birmingham, Ala. This city has become an industrial center due to the closeness of iron ore and coal, as well as an adequate local supply of labor. Other large iron works and steel plants are scattered over the United States, but are located either in the vicinity of an iron or coal mining region or of a large industrial center.

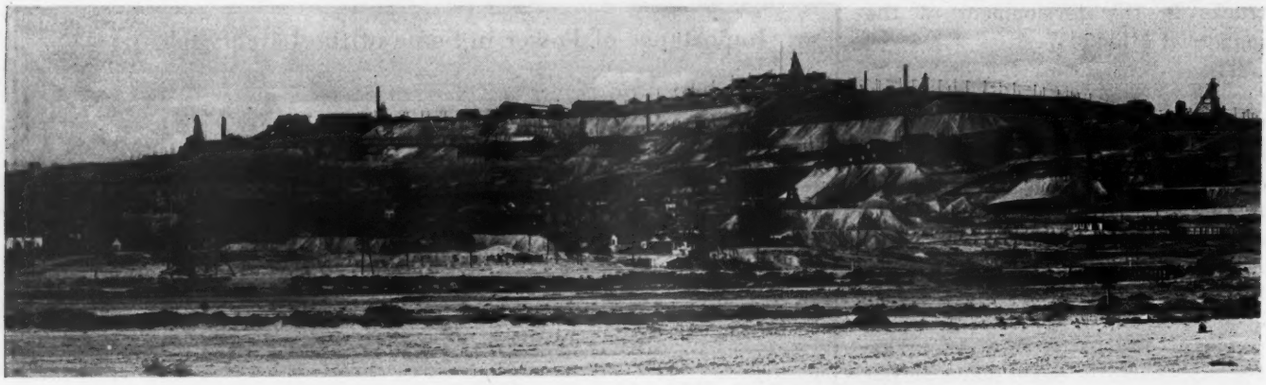
Many other instances of the centralization of an industry are prominently identified with the expansion of certain industries in the United States. Part of this centralization was due to the feeling that where a number of industrial plants engaged in similar work were located in a neighborhood there would be a larger supply of semi-trained labor available, as men could shift from one plant to another, and take advantage of their former experience. While this is still of advantage, many concerns now prefer to build up in smaller towns and develop a more steady force of home-owners and workers, instead of depending upon a more or less shifting crew. Also the cost of land, and frequently buildings, is lower than in a larger city. Most large cities, however, have a fringe of industrial developments on the outskirts which take advantage of both large city and small community life. The city of Chicago is a typical example with its large industrial works at Gary, East Chicago, Hammond, Whiting, Chi-

Importance of Power in Some of the Larger Industries

Industry	Number of Establishments	Primary Horsepower		Cost of Fuel or Purchased Power	Value of Product
		Total Hp.	Electric Hp.		
Agricultural Implements	497	128,249	100,263	$ 5,038,512	$ 304,961,265
Automobiles, Parts and Bodies	2,579	542,224	490,560	25,320,519	3,304,726,138
Brick, Tile, Pottery and Clay Products	2,572	439,194	148,061	39,807,324	283,342,106
Car and R. R. Repair Shops	1,470	594,515	500,141	31,400,634	1,279,235,393
Cement	117	488,808	345,535	31,074,596	175,264,910
Chemicals	486	376,940	235,973	32,742,310	438,658,869
Cotton Goods	1,482	1,863,542	874,124	37,843,442	2,166,179,028
Electric Machinery, Apparatus, Supplies	1,345	438,839	479,366	13,739,110	997,968,119
Flour and Grist Mills	10,673	876,405	309,610	15,279,876	2,052,434,385
Foundry and Machine Shops	10,934	1,886,983	1,725,145	48,365,702	2,289,250,859
Furniture	2,867	275,935	143,691	6,595,339	597,405,141
Ice, Manufactured	2,778	572,970	158,552	25,606,264	137,004,798
Iron & Steel, Blast Furnaces	193	1,581,432	242,554	235,623,653	794,466,558
Iron and Steel, Steel Works and Rolling Mills	499	3,820,917	2,350,596	156,964,862	2,828,902,376
Lumber and Lumber Products	30,417	2,930,186	543,903	12,904,562	1,887,909,671
Paper and Wood Pulp	722	1,851,014	583,586	54,999,955	788,059,377
Printing and Publishing	24,636	362,123	331,500	12,251,441	1,536,408,283
Rubber Tires and Goods	404	354,188	304,367	12,605,943	987,088,045
Shipbuilding	934	553,711	476,135	15,604,092	1,622,361,361
Slaughtering and Meat Packing	1,004	371,925	223,769	24,089,789	4,246,290,614
Woolens and Worsteds	835	486,480	239,391	15,398,068	1,065,434,072
Smelting and Refining Copper	33	321,610	184,255	19,243,024	651,101,591
Total—All Industries	237,854	29,504,792	16,317,277	$1,645,986,556	$62,418,078,733

McGraw-Hill Compilation of Motors Installed in Industrial Plants in the United States

Industry	Motors Run by Purchased Energy		Motors Run by Energy Generated in Private Plants		Total Motors in All Plants		Distribution of Drives			
	Number	Total Rating, Hp.	Number	Total Rating, Hp.	Number	Total Rating, Hp.	Motors Under 5 Hp.	Belt, Number	Chain, Number	Directly Connected, Number
Agricultural implements	4,594	47,842	3,399	52,421	7,993	100,263	2,012	3,632	241	4,120
Chemicals and allied products (total)	73,019	1,235,704	60,827	962,164	133,846	2,197,868	40,500	78,576	8,120	47,150
Rubber and rubber products	9,711	194,018	7,355	162,608	17,066	356,626	.....	.....	.....	.....
Glass and glass products	8,378	69,714	6,395	90,713	14,773	160,427	.....	.....	.....	.....
Chemicals	27,597	377,523	20,306	267,315	47,903	644,838	.....	.....	.....	.....
Smelting and refining of metals	5,058	173,495	4,787	111,768	9,845	285,263	.....	.....	.....	.....
Artificial gas manufacture	1,413	33,363	1,822	22,040	3,235	55,403	.....	.....	.....	.....
Miscellaneous chemical industries	20,862	387,591	20,162	307,720	41,024	695,311	.....	.....	.....	.....
Electrical equipment and machinery	42,023	235,605	38,472	243,761	80,495	479,366	46,400	47,931	764	31,800
Food and kindred products	118,234	1,056,146	37,589	392,560	155,823	1,448,706	68,500	93,493	20,330	42,000
Iron and steel and their products	166,794	2,376,931	124,199	2,579,474	290,993	4,956,405	73,230	131,993	8,800	150,200
Leather and its products	23,057	144,635	11,505	120,355	34,562	264,990	13,880	31,298	1,754	1,510
Lumber and its products	45,878	462,777	23,079	323,186	68,957	785,963	25,400	50,449	2,678	15,830
Liquors and beverages	14,420	87,718	11,164	85,898	25,584	173,616	11,230	15,344	3,340	6,900
Metals and metal products other than iron or steel	56,991	543,574	21,016	223,485	78,007	767,059	40,490	55,680	3,887	18,440
Bituminous and anthracite coal mines	23,088	889,539	24,849	893,214	47,937	1,782,753	16,640	12,712	1,825	33,400
Metal mines	11,274	507,461	5,599	273,241	16,873	780,702	5,850	4,501	642	11,730
Stone quarries	3,971	156,810	490	19,210	4,461	176,020	1,548	1,228	170	3,063
Miscellaneous mines and quarries	932	30,636	771	46,635	1,703	77,271	591	454	65	1,184
Petroleum and natural gas	1,849	45,134	1,330	28,166	3,179	73,300	1,103	848	121	2,210
Paper and printing	160,151	623,706	27,768	413,835	187,919	1,037,541	95,600	150,879	8,040	29,000
Railroad-shop construction and repairs	19,187	325,313	25,558	404,349	44,745	729,662	5,615	13,020	1,790	29,935
Stone and clay and their products	21,440	563,263	7,947	225,365	29,387	788,628	9,420	16,817	3,720	8,850
Textiles	157,760	959,845	69,019	720,952	226,779	1,680,797	136,800	100,609	18,170	108,000
Tobacco	3,382	14,430	1,842	13,447	5,224	27,877	3,532	4,543	114	567
Vehicles for land transportation	61,408	475,853	14,199	125,976	75,607	601,829	36,520	45,977	4,150	25,480
Miscellaneous	27,662	194,214	9,456	82,599	37,118	276,813	20,750	20,328	2,460	14,330
Totals for all manufacturing industries, mines, quarries and wells of U. S.	1,037,114	10,977,136	520,078	8,230,293	1,557,192	19,207,429	655,611	880,312	91,181	585,699



The city of Butte, Mont., which owes its growth to the copper mining and reduction developments surrounding it.

cago Heights, Harvey, Cicero, Joliet, Aurora, Elgin, Waukegan and North Chicago.

Although slaughtering and meat packing is the largest single industry in Chicago proper and iron and steel products the largest for the surrounding district a wide variety of miscellaneous industrial developments have centered here due to the central location. Chicago is a big railroad center with direct transportation to almost every part of the United States. The Lake transportation is also an important reason for the growth of this district. Boston, Philadelphia, Baltimore, New York City and many other large cities have a similar fringe of industrial towns surrounding them.

Today transportation to market and transportation of raw materials are two of the most important factors in deciding on plant location. For example: Minneapolis, Minn., was and still is the center of the flour milling industry. This was largely due to its location at practically the only available water power site in the Middle West and also to its closeness to the big wheat-producing sections. The works now at Niagara Falls and Keokuk (Iowa), on the Mississippi River are comparatively recent and due to water power developments at these points.

Labor required is not a big element in flour milling; power and supply of wheat are. The flour market is everywhere. Wheat is easier shipped than flour and as freight rates increased it was but natural to start flour milling centers elsewhere until now there are two other important centers, although they are not as large as the first. These are around Buffalo, N. Y., and around Kansas City, Mo., and in Kansas. The Kansas milling center has the advantage of being in the center of the wheat fields and also it has a big flour market around it. Power is no cheaper but transportation on both wheat and flour is lower. Buffalo, N. Y., is at the end of lake transportation which is much cheaper on bulk wheat than on flour and also is near the center of the Eastern flour market. Niagara Falls offers a low power cost.

A flour milling industry of considerable size has been developed on the Pacific Coast for similar reasons. Also many small flour mills are being erected over the country to take advantage of local supply and market. There seems to be a decentralization of this industry. Cost of freight or transportation is probably the principal reason for this decentralization in flour milling as well as in some other industries. It is much cheaper to ship the coal and raw materials considerable distances if freight transportation on the finished product can be materially reduced. Raw material and coal go at cheap bulk freight rates while most finished products have a higher shipping cost and are frequently easily damaged and more bulky, as for example shoes in cartons compared with leather. Comparatively recent and important shoe centers are being built up around St. Louis, Mo., Milwaukee, Wis., and Chicago, Ill., although Massachusetts and New York have been the centers of the shoe industry.

There are many other industries which have attached themselves to certain localities or cities so that a reference to the city almost instantly calls to mind the product. For example: Akron, Ohio, is associated with the rubber industry; Grand Rapids, Mich., with the furniture industry; Pittsburgh, Pa., with steel; Lowell, Mass., and Charlotte, N. C., with the cotton mill industry; Denver, Colo., Butte, Mont., and Salt Lake City, Utah, with mining; Hollywood, Calif., with motion pictures; Chicago, Ill., with meat packing; Rock Island and Moline, Ill., and Davenport, Ia., with agricultural implements; Battle Creek, Mich., with breakfast food, and so on. This does not mean that these are the only industries of these cities, but that those mentioned are among the more prominent.

Detroit, Mich., for example, is associated with automobiles, although it has numerous other large industrial plants. This year the total output of Detroit plants was valued at about $2,000,000,000 and a large proportion of this was automobiles and automobile parts. Detroit got an early start in this industry and many of the largest automotive concerns have established their main plants there. Many other automotive concerns are established in other Michigan cities such as Lansing, Flint and others.

The tendency today, however, seems to be toward building large assembly and semi-manufacturing branch plants in other sections of the country. Ford, for example, has built a large plant in the Chicago district and is building a plant to utilize the water power on the upper Mississippi River, above Minneapolis and St. Paul, Minn. Other sub-plants are built in other sections of the country. These take advantage of being nearer the market as the freight rate on an automobile from Detroit to Kansas City, Mo., or any other city, is much less when shipped to the assembly or branch plants as raw material or unassembled parts than if it were shipped as a finished automobile.

To reduce freight rates is today one of the most important reasons for establishment of plants in any location, as now power can be obtained almost anywhere at about the same cost. Also in many industries, particularly light manufacturing, power is a small item of expense.

Many other centers have been built

up to take advantage of freight savings. For example, Los Angeles, Calif., is becoming an important branch factory or warehouse center for concerns distributing to the Pacific Coast and to foreign countries. The Goodyear Tire & Rubber Co. a few years ago built a large branch factory at Los Angeles. Kansas City, Mo., and Omaha, Neb., have, for the same reason, become centers for the territory between them and the Rocky Mountains. Similarly, Baltimore, Md., has had a rapid growth industrially as it has become a big exporting center, although New York City and its industrial community holds predominence. Baltimore gets many export shipments because it is closer to Chicago, Ill., and the Central West than is New York City.

Cheap power has been an important factor in the establishment of chemical and reduction plants in the Niagara Falls, N. Y., power district. In many of them the electric furnace is essential and is a big consumer of electric energy. Several similar industries have been built up in the Keokuk power district on the Mississippi River and in the West.

Because a city ranks high in any industry does not mean that it will always hold the field. Cincinnati, Ohio, for example, was once the leading meat-packing city. However, today over two-thirds of the livestock is raised west of the Mississippi River and a comparatively small amount in Ohio. Therefore, the big meat centers are Chicago, which lies between the hog, cattle, and sheep raising section and the market, and Omaha, Neb., and Kansas City, Mo., which are directly within the stock raising territory. Power is a small factor even though mechanical refrigeration takes an important part in the slaughtering and packing industry. Today Cincinnati is a leader in the machine tool industry, however, slaughtering and meat packing is still one of its largest industries.

The cement industry is one prominent example of an industry which is widely scattered over the country. The raw materials are found in many parts of the country and are quite heavy. The finished product is heavy, too, and its selling price is too low to permit much transportation expense. Therefore, cement plants are carefully located over the country where the cost of transportation for raw materials, coal and of the finished material to the market are carefully balanced. For this reason the plants are widely scattered over the country, usually near some large city so that they can supply the local building and paving demands. Several mills may be near large cities like New York and Chicago because the market is so large.

Coal for burning the cement and for power is a big item as it requires about 50 lb. of coal for each 100 lb. of cement. This makes the cement industry one of the largest users of power relative to the value of product handled. The blast furnace industry is the largest user of fuel and power as will be seen from the accompanying tables. The coking industry, which is practically all fuel, ranks second in total value and the steel works and rolling mills, third.

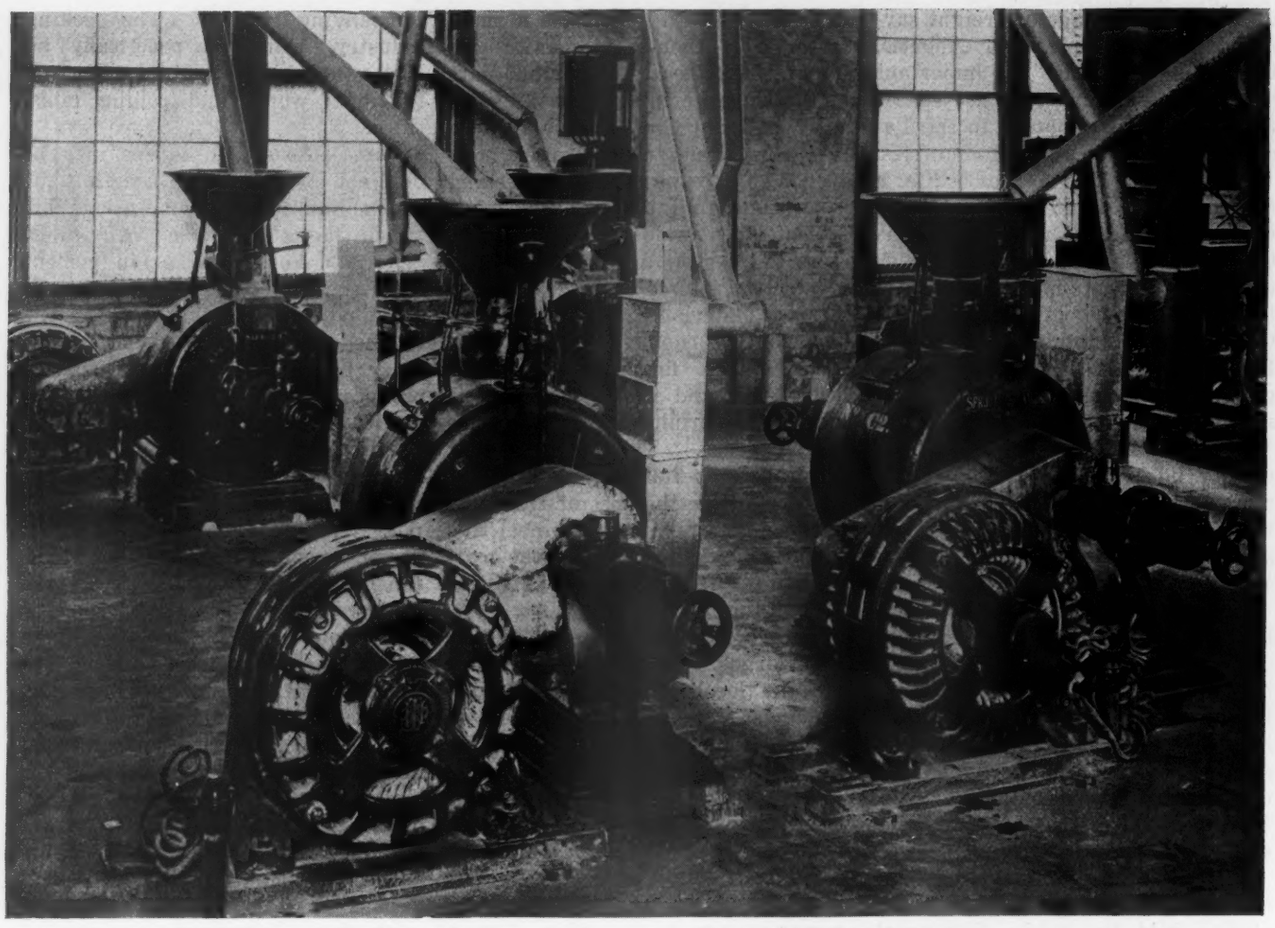
Some interesting figures may be obtained by carrying through some of the additional computations between the figures given in the table, page 9. For example, in cement mills the cost of fuel and power is 17.25 per cent of the value of the finished product. Also, each primary horsepower in plant capacity produced only $350 worth of product. In ice manufacturing, which uses practically all its fuel for power, 11.4 per cent of the value of the finished product is expended for fuel or power. Here each primary horsepower capacity produces only $240 in finished product annually. On the other hand each primary horsepower in the flour milling industry produces $2,344 worth of finished product.

The industry manufacturing brick, tile, pottery and other clay products also is a large user of power in that 14 per cent of the total value of the finished product goes into power and fuel. Each primary horsepower produces about $655 worth of finished product. At the time this census was taken only about 34 per cent of this industry was electrified, whereas about 70 per cent of the cement industry is electrified. However, in the period from 1914 to 1919 the amount of electrical horsepower used in the brick and other clay products industry increased from 86,779 hp. to 148,061 hp.

Six industries, as may be seen from the table on page 9, each show more than 1,500,000 horsepower. *(Continued on page 46)*

One of the largest petroleum refining plants.

This is the Bayonne, N. J., refinery of the Standard Oil Co. This is an industry which requires large amounts of fuel for heat rather than for power. Oil refineries are distributed over the country near the market as the crude oil is transported in bulk in ships or pipe lines while the refined oil must be more carefully handled.



The motor on the left is equipped with ball bearings while the motor on the right has sleeve bearings. Which type of bearing will prove superior in the long run? Both motors were made by Fairbanks, Morse & Co.

Designers and Operators Comment on the Question—

Do Ball and Roller Bearings Justify Their Cost

When Used in General-Purpose Motors?; Together With a Discussion of the Points of Comparison Between Ball, Roller, and Sleeve Bearings

By HOWARD MAXWELL

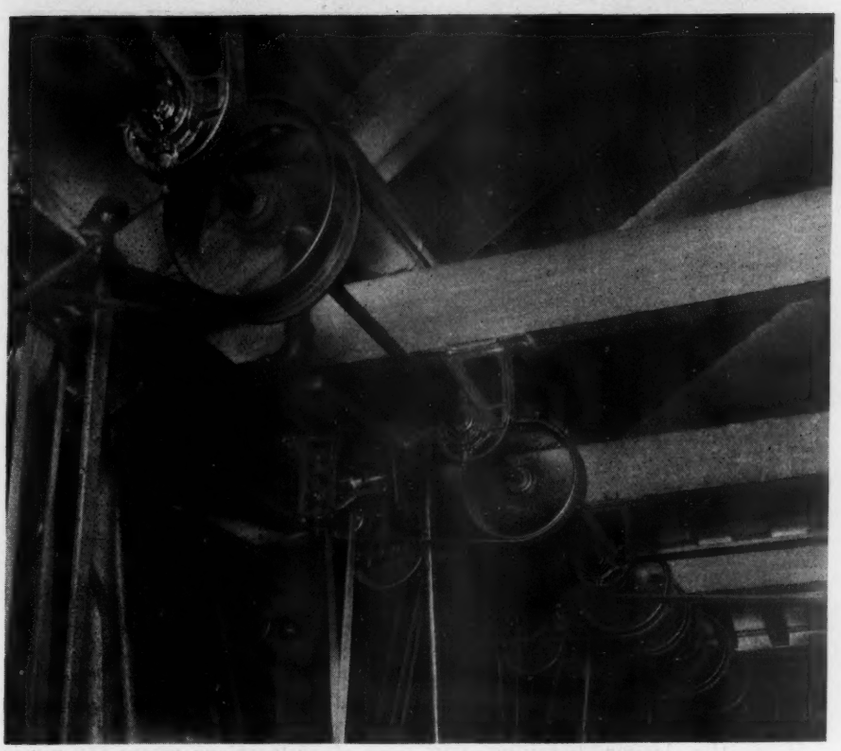
Designing Engineer, Induction Motor Department, General Electric Company, Schenectady, N. Y.

DURING the past 20 years or so, motor designers have endeavored to substitute ball or roller bearings for sleeve bearings for certain kinds of service and in certain types of machines. It is safe to say that the extent of their progress in this direction has been in direct proportion to the success attending their efforts in the use of these types of bearings. The most ardent proponents of ball and roller bearings have been impatient at times over what seemed to be the slow progress made in introducing these bearings into general motor use, but I think that even they would agree with me that if ball and roller bearings had been applied to all motors 15 or 20 years ago with the limited knowledge and experience available at that time, the results would have been very detrimental to the ball and roller bearing interests as well as to the motor industry.

There is today a growing demand for general-purpose, industrial motors equipped with ball or roller bearings, and many motor manufacturers who have not regularly supplied them heretofore are weighing the need of meeting this demand in their standard lines, so that it is well to consider at this time the progress that has been made in the use of ball and roller bearings.

The greatest assurance of success in the introduction of ball or roller bearings into standard lines of motors at this time lies in the fact that the designers of these bearings now agree on many details on which there was in the past a wide diversity of opinion. Among these details may be mentioned the following:

Lubrication.—It is now agreed that light grease is to be preferred for use on general-purpose motors operating below 2,000 r. p. m. It forms a better seal against the intrusion of grit, and as it is less likely than oil to escape from the housing, less frequent replacement of the



Here is a long lineshaft equipped with Strom ball bearings.
It is said that reduced maintenance is obtained through the use of ball or roller bearing hangers on lineshafts.

lubricant, and consequently less attention, should be required. One of the principal advantages so far developed for ball or roller bearings over sleeve bearings as heretofore made, is in their so-claimed freedom from oil or grease leakage which finds its way onto the windings of the motor and causes insulation trouble. In order to make good on this claim where grease is used, it will be necessary to educate the motor users not to overfill the bearings, as there is no way to limit the quantity of grease inserted, as can be done with oil lubrication where overflow gauges are used to determine the oil level.

Standardization of Sizes.—During the past year the principal makers of ball bearings have all agreed to a list of sizes of bearings to be used with the different motor ratings. This list combining as it does the knowledge and experience of the many ball-bearing engineers into a single recommendation, is of the greatest assistance to motor designers and gives assurance to all that we are now better prepared to extend the use of ball and roller bearings than we have been heretofore.

This standardization of sizes is of the greatest importance to motor users in that it simplifies the problem of renewal bearings. Most of the ball bearings and some of the roller bearings are now interchangeable with each other, and if motor makers use the same size bearings, or at least the same series of bearings, it becomes very easy to provide for supply parts. For this act of standardization we are indebted to the suggestions and help given by the steel-mill electrical and mechanical engineers.

Assembly.—It is commonly accepted that the inner race should be assembled on the shaft under a very light pressure fit, such as would be secured where the shaft is about 0.0005 in. larger than the inside diameter of the inner race. This will prevent it from rolling on the shaft as it alternates from loaded to unloaded side. In addition it is generally recommended to further secure the inner race between a clamping nut and a shoulder on the shaft.

The success or failure of ball bearings is closely allied to the manufacturing tolerances and assembly fits, as you probably all well know. If a 1-in. cube of steel be compressed so that its length is shortened 0.0001 in. it is being loaded 2,800 lbs. With this fact in mind you can picture the effect of any slight inaccuracies which tend to cramp the balls, and see that such unnatural loads may very easily exceed the normal capacity of the balls. I am quite confident that ball and roller bearing makers understand and are able to meet the tolerances required, and it is an evidence of their appreciation of the practical side of this that they now make the ball or roller clearance between raceways a little more free so that we can press the inner race onto a shaft where it is a little bit over normal allowance without cramping the balls.

Enclosures.—In the details of the enclosing covers at the ends of the bearing housing there may yet be some slight difference in methods of grooving recommended, but even here they all follow along the same general lines.

Ball- or roller-bearing-equipped motors now designed according to the above standardized practice and using the recommended sizes of bearings which are *one to three sizes larger than those commonly used before* should, it would seem, give satisfactory service. So it is no longer a question as to whether ball and roller bearings will or will not work satisfactorily in motors, but rather the question is whether or not the ball and roller bearings offer advantages over sleeve bearings which warrant their general use in the face of greater initial cost of the motor. I will confess that I do not know a simple answer to this question, and in fact I think it will require much more extensive use of ball or roller bearings in general-purpose motors than now exists in order to establish

MANY USERS of bearings are now asking the question which is embodied in the title of this article. In this article Mr. Maxwell states the factors that should be considered when deciding the question for a given bearing application. This discussion was presented at a joint meeting of the Chicago Section of the American Society of Mechanical Engineers and the Western Society of Engineers held in Chicago. L. A. Hillman, Research Engineer of the Strom Ball Bearing Company, presented at this meeting a paper which will be given in a succeeding issue of INDUSTRIAL ENGINEER. Arthur Williams, Chief Engineer of the Shafer Bearing Corporation, gave a third paper which has been abstracted and precedes the discussion of all three papers at the end of this article.

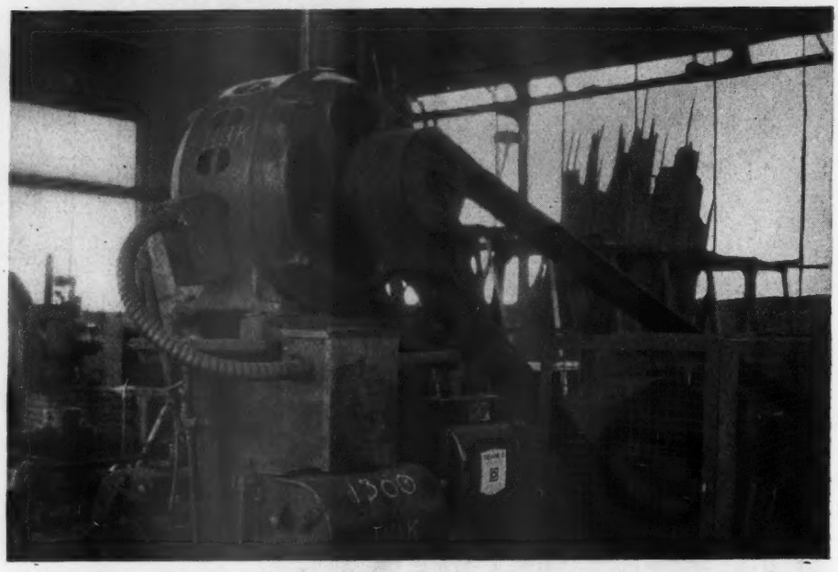
the comparative value of the various claims of superiority. However there are several points of comparison which are commonly made and can be intelligently discussed in the light of present experience.

Saving in Friction Loss.—I mention this first because it was one of the first claims made for ball and roller bearings. In fact, even today these bearings are commonly known and designated as anti-friction bearings. This idea originated perhaps because their static or starting friction is so low that it was quite natural to assume that they would have little or no friction under full speed. It was a great disappointment to motor designers to find out many years ago, when they first equipped their motors with ball and roller bearings, that these bearings had about the same friction loss as the oil-ring lubricated, sleeve bearing. We made very careful tests then, both at no-load and with the bearings carrying the load of a heavy flywheel. In making the load tests the motor with sleeve bearings and fly wheel assembled on the shaft was allowed to coast from full load to zero speed without power supply, and a deceleration curve plotted between time and speed. A similar deceleration curve was also taken with the same motor and fly wheel, but using roller bearings.

It was found after repeated check tests that a reduction in speed from 1,800 r.p.m down to 600 r.p.m. required 20 min. with either type of bearing, but from 600 r.p.m to zero speed the sleeve bearing stopped in 26 min. and the roller-bearing motor stopped in 38 min.

Many later tests made at no-load on both ball-and roller-bearing motors indicate that there is no appreciable difference in the friction loss of either type in motors operating at moderate or high speeds. We have taken the trouble to check motors of other than our own make equipped with both ball and sleeve bearings and find that they likewise show no difference in running friction loss.

Over-All Length of Motor.—When ball bearings were first used many years ago, it was quite common to recommend much smaller sizes, and also lighter series of bearings than is customary today; so the impression was then formed that they afforded a means of shortening up the over-all length of motor because being small in diameter they could be extended farther inside the motor.



Many motor users are putting ball or roller bearings on their motors in an attempt to reduce motor maintenance.
This motor, which drives a punch, is equipped with Strom ball bearings.

With the larger bearings now standardized and commonly used, the outside diameter of the bearing housing is too large to extend inside the rotor windings and so it has been our experience that the dimension of length over the bearing housings cannot be made less on the ball- and roller-bearing motors, at least in the smaller sizes, up to 50 hp.

Smaller Air Gaps.—It has been proposed to reduce the radial clearance or so-called air gap between the rotating and stationary members of a motor where ball or roller bearings are used, and therewith rearrange the design to reduce the cost or improve the motor characteristics and thereby profit by this reduction. The air gaps now commonly used in induction types of motors are now quite small and are generally thought to be the minimum required by considerations other than bearing wear or clearance. They vary from about 10 or 12 mils on a 1-hp. motor up to about 30 to 35 mils on a motor of 50-hp. capacity. I have yet to find a designer who had the courage to make the clearance much smaller with any kind of bearings. On direct-current and synchronous motors the air-gap clearances are much larger, but they are set by electrical requirements and would not be made smaller with other types of bearings.

Maintenance Costs.—When we take up the subject of maintenance costs we will find data presented and opinions expressed by those using motors in certain classes of service which show a very considerable advantage on the side of ball and roller bearings over sleeve bearings. This advantage appears in motors used in foundries, steel mills, cement mills and other locations where the air is laden with gritty dust. I believe that this kind of service offers the most promising field for the immediate extension in the use of ball- or roller-bearing, general-purpose motors.

It is not argued that ball and roller bearings suffer less from the effects of grit in the lubricant, but that the form of enclosure and the use of grease instead of oil prevent the entrance of grit into their housings. The designers of ball and roller bearings have thus indicated to the designers of sleeve bearings the need of more attention to dirt seals and in the past several years this detail has received more intelligent consideration so that the modern, sleeve-bearing motor is much improved over its predecessors in this respect. It is often contended that the present comparison of bearing life in dirty places is based on old designs of sleeve-bearing motors, but it seems to me that even so it still remains for sleeve-bearing designers to prove that their bearings are or can be made equal to ball and roller bearings in this respect.

Where the bearings fail and have to be replaced every few months, as has been occasionally reported, the maintenance cost runs into very large figures each year, and it then overshadows all other considerations. And in plants suffering acutely from such trouble I do not expect those responsible for maintenance to give much weight to other points favor-

ing sleeve bearings. However, the number of motors located in such extreme conditions of grit-laden air are few as compared with the many in comparatively clean air, and thus the importance of this advantage becomes less when considered for a complete line of general-purpose motors.

Oil Leakage.—The escape of the lubricant from the bearing enclosure of sleeve-bearing motors is also largely a question of the design and manufacture of the housings.

A certain amount of this kind of trouble is due to careless filling of oil wells. The oiler frequently spills oil over the outside of the motor and many of them add oil too often when the motor is running. It seems possible that more trouble may arise due to too frequent oiling of motors than due to lack of attention causing the oil wells to run dry. So much has been said along this line recently that I have been watching a 15-hp. motor which runs continuously and which has now been operating nine months without addition to or change of oil, and judging from the amount of oil that has evaporated or escaped in any way so far, I expect that the motor will run another year without adding oil. This motor is not special in any way; it is equipped with the present standard design of sleeve bearing.

I think too much insulation trouble has been charged to the effect of oil on windings. While oil does tend to soften some kinds of insulating varnish and may in certain bad cases be the prime cause of insulation failures, still I do not think it is nearly so serious as a great many people have been led to believe.

Whether or not ball and roller bearings have and can maintain a just claim to advantage over sleeve bearings in this respect hinges on whether the attendants over-fill them with grease. When grease is inserted through a plug or high-pressure grease fitting, there is no indication that the proper amount of grease has been applied until it appears at the openings around the shaft. It is our observation that ball bearings are also generally over-lubricated. Grease is surely as detrimental as oil to the insulation of all coils.

Life of Bearings.—It would require a great deal more data than I have available, and in fact than I believe is available anywhere, to compare intelligently the life of sleeve bearings with ball or roller bearings used in motors. We know of a few ball- and roller-bearing motors that were built 10 to 15 years ago and are still running satisfactorily. We also know of some of the first induction motors sent to one of the southern textile mills over 30 years ago which have run continuously during the daytime and much of the time at nights, at a constant overload of 25 per cent; a recent investigation showed that six motors out of the 14 were running yet on their original sleeve bearings.

All this is interesting, but it does not add much useful knowledge on the life of bearings. We need to know what percentage of bearings, ball, roller, or sleeve, fail the first year, what percentage the second year and so on, but such data is not available for very many motor applications.

I have mentioned the life of bearings in order to bring out a point which has often occurred to me when considering ball and roller bearings. The journal of a sleeve bearing runs on a film of oil which separates it from the bearing surface, and under ideal conditions there can be no wear or deterioration in the bearing or journal; under such conditions its life is, therefore, infinitely long. In a ball or roller bearing the parts are in metal contact and are subject to rapidly-repeated stresses which deform the surface and bring into operation the laws of fatigue of metals. These laws teach us that metals subjected to repeated stresses eventually break down after a given number of repetitions of the stress, depending upon the magnitude of the maximum stress; therefore ball and roller types of bearings do have a certain, definite, useful life.

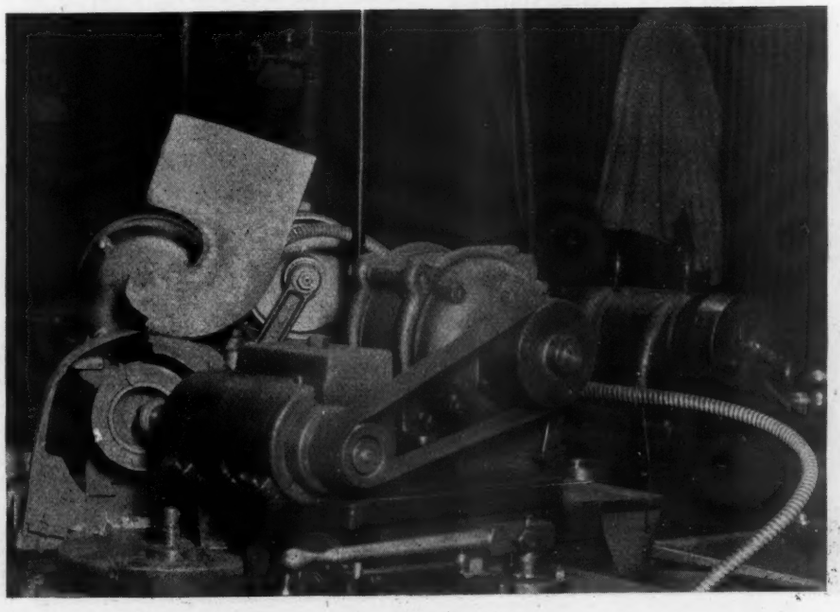
This is not an argument against the use of ball or roller bearings in itself, but it simply emphasizes the necessity of selecting ball or roller bearings large enough to avoid the overstressing of the parts.

I was very much pleased to find reference to this in a paper by Mr. Brunner printed in the May issue of the *Iron and Steel Engineer*, and to realize that the ball bearing engineers had investigated the life of bearings on the basis of fatigue. I believe we can, therefore, trust that their present-day recommendation as to sizes is on a very conservative basis of load rating.

Vibration and Noise.—Vibration is more readily carried through a shaft supported on ball bearings than through one cushioned on an oil film in a sleeve bearing. This is especially true for such periodicity of vibration as may be encountered with spur gearing and some of the worst cases we have encountered have been severe enough to crystallize the rotor windings. The noise made by the motor also is more noticeable with ball than with sleeve bearings. However, these points can generally be satisfactorily overcome if given proper consideration by the motor designer.

Cost.—The difference between a

This grinder motor would not start its load until the motor was equipped with ball bearings.
The motor is rated at 1½ hp., 3,600 r.p.m., and is equipped with Strom ball bearings.



standard, horizontal, general-purpose motor equipped with ball or roller bearings, and one equipped with oil-ring lubricated, sleeve bearings, will vary somewhat with different companies, depending upon the development of their equipment and methods of making sleeve bearings and when expressed as a percentage it will, of course, vary considerably with the size and type of motors compared. I can however say with a fair degree of accuracy in approximation that on the squirrel-cage, or most popular type of motor now used today in sizes up to 50 hp., the cost will be increased at least 10 per cent by the substitution of ball or roller for sleeve bearings.

I realize that most of you are more interested in selling price than in manufacturing cost and that selling expediency may for a while establish prices on another basis, but I am sure that eventually the economic laws must bring selling prices in line with the cost of manufacture, in this case at least.

We cannot help admiring the ball and roller bearings made today as wonderful mechanisms excelling by far the precision attained in any other parts regularly produced for our machinery. It has required scientific and untiring attention to detail to develop the processes of heat treatment, manufacturing methods and machinery as well as careful inspection and testing devices.

These factors contribute to the high quality built into these bearings today and enable their makers to produce them at what seems to me so reasonable a cost. Perhaps their ingenuity will yet enable them to go further and produce the same high quality of bearings at even lower cost and, if so, this will greatly assist in promoting the use of them in industrial motors.

In the foregoing remarks I do not wish to convey the impression that there exists today any very great difference of opinion between ball or roller bearing manufacturers and motor manufacturers on the relative merits of the different kinds of motor bearings, because I feel that the many papers written, as well as the discussions and conferences held between them during the past year, have very effectively cleared up these divergent viewpoints.

Main Points in Discussion of Ball, Roller and Sleeve Bearings

Following Mr. Maxwell's paper, a paper on "Ball Bearings" was presented by L. A. Hillman, Research Engineer, Strom Ball Bearing Company, Chicago, Ill. Mr. Hillman's paper will be given in a succeeding issue of INDUSTRIAL ENGINEER.

A third paper was presented by Arthur Williams, Chief Engineer, Shafer Bearing Corporation, Chicago, Ill. His paper was on "Roller Bearing Application to Industrial Uses" and is abstracted in the following:

With the increased cost of labor and material, the engineer is called upon to design machinery requiring less skilled operators, less maintenance and which, at the same time, will have greater capacity and longer life. To attain these ends, he is turning more and more to anti-friction bearings.

Many of the failures of bearings have been due to faulty application. A large amount of this has been due to lack of knowledge on the part of the user of the necessary care in machining of component parts, improper fitting, lack of provision for sufficient lubrication, and of improper grease or oil for the lubrication.

Fitting processes for different bearings vary greatly. For instance, a deep-groove ball bearing must not have a tight press fit on either the inner or outer race. The running clearance of the balls is so little that any expansion or contraction of the races will severely overload the bearing and cause an early failure. With ball or roller bearings of the adjustable type, the revolving member is generally a good press fit and the stationary member a creeping fit so as to allow for adjustment. Some roller bearing manufacturers recommend a press fit for all cups to counteract the bursting action caused by the thrust of the rollers.

Load capacity of the bearing cannot always be determined from a table because of so many unknown factors such as shocks, reversal of load, distortion, shaft whip, possible misalignment, and other causes that may come up. For this reason, most bearing engineers prefer to make recommendations on past practice. Where bearings are to be installed by millwrights or shop mechanics they are likely to be abused while being installed. For this reason, bearings going into such hands should be made as near foolproof as possible, even to the extent of making the entire assembly a detachable unit which need not be dismantled to be put on or taken off the shaft. Careful instructions should be issued on the mounting of bearings in order to make sure that they are pressed on or pulled off, for in many shops the sledge is often closer than the arbor press or the wheel puller.

Because the industrial field is so large and covers such diversified classes of machinery, it is impossible for one type of bearing to cover the field. The best bearing to apply at a given point is a matter to be determined by the engineer. In most cases any type of bearing can be used, the

Here is a lineshaft subjected to the strain and shock of large stamping machines.

The lineshaft is equipped with Fafnir double ball bearing hanger boxes.

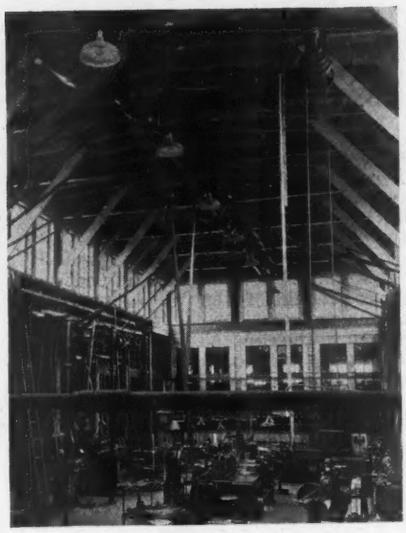
main question is, which bearing best suits the requirements of the application under consideration. Some of the determining factors that must be considered are:

Space.—Certain applications are largely determined by the space allowable for bearings. With little space between shaft and housing, and with unrestricted length, a non-adjustable type of bearing is required. Again where the overall length of the machine is important the narrowest bearing that will carry the load is required. In this case practically any type of roller bearing can be used. Often the bearing installation is such that the bearings, when once installed, are very difficult to get at. Here an adjustable bearing would be inadvisable. On the other hand assemblies are sometimes made much simpler and the construction of the entire machine can be simplified by the use of adjustable bearings. These factors must be gone over with the layout engineer.

Manufacturing Practices.—The type of machinery being built more or less determines the bearing best suited for the application, although no set rules can be given along this line. Generally, however, mill and elevator machinery makers cannot use to advantage as fine a type of bearing as can a machine-tool builder, whose product is noted for extremely fine workmanship and accuracy. Occasionally, however, rough machinery has been wonderfully improved by the use of high-grade, roller bearings.

Cost of the Bearing and Its Application.—The cost of the bearing is very small compared to the saving that it will make. For this reason, it is well to consider the bearing in the light of manufacturing requirements. One type of bearing may simplify the manufacture of the product or simplify the design or assembly of the machine. Here, again, different bearings can show advantages over others. On some applications, where alignment is hard to secure without greatly added expense, the bearing that will take care of slight misalignment has a decided advantage.

Efficiency and Maintenance.—It is not alone the saving of power that determines whether to use plain bearings or roller bearings. In many cases the saving in maintenance on large installations is a much greater factor than the saving of power. On the other hand, if the power saving is the primary factor, then the most efficient type of roller bearing should be used, depending on the service to which the bearing is to be put. The efficiencies of different types of roller bearings vary greatly, and no set of figures can be given which could be considered absolutely reliable. This is because certain factors come up that have decided influence on their efficiency. For example, misalignment of housings or severe deflections of shaft will cause a decided drop in efficiency of a solid roller bearing of either cylindrical or tapered-roller type because of pinching of the rollers. On the other hand, this same misalignment will cause practically no change in the efficiency of self-aligning bearings.



Reduced starting friction is an advantage of ball and roller bearings.

When the lineshaft shown here was equipped with sleeve bearings, the starting friction was such that it was necessary to pull the belt by hand to get the lineshaft under way. The lineshaft was then equipped with Fafnir double ball bearing boxes and the starting friction lowered so that it was unnecessary to install a larger or different type motor.

Lubricants used should be of just sufficient consistency to stay in the housings, for in any anti-friction bearing the principle function of the lubricant is to prevent drag of the retainer and to prevent corrosion of the bearings. The class of grinding finish on the bearings is also another factor which will change the efficiency somewhat. A roughly-finished bearing of the same type will show a lower efficiency than a highly-finished bearing.

Installation.—The mountings of roller bearings vary with different types and should be in accordance with the recommendations of the manufacturers of the bearing to be used. A few general principles that should be followed are to make sure that there is ample provision for lubricant. If possible this lubricant should be so supplied that it will be able to circulate or distribute itself throughout the bearing and should the bearing run warm enough to melt, will not run out. Proper foresight along this line will insure the bearing running over long periods of time with little or no attention. Different kinds of grease retainers are being used, depending on the application. In some installations a felt ring is very satisfactory. This should be run on the shaft and should have just sufficient pressure to create an oil film and prevent the oil working out. Leather cup packings are being used successfully and where water or grinding compound is encountered the felt packing can be used with the addition of some type of labyrinth or slinger to positively throw the water away from the bearing while in operation and so designed as to prevent water from draining into the bearing when not running.

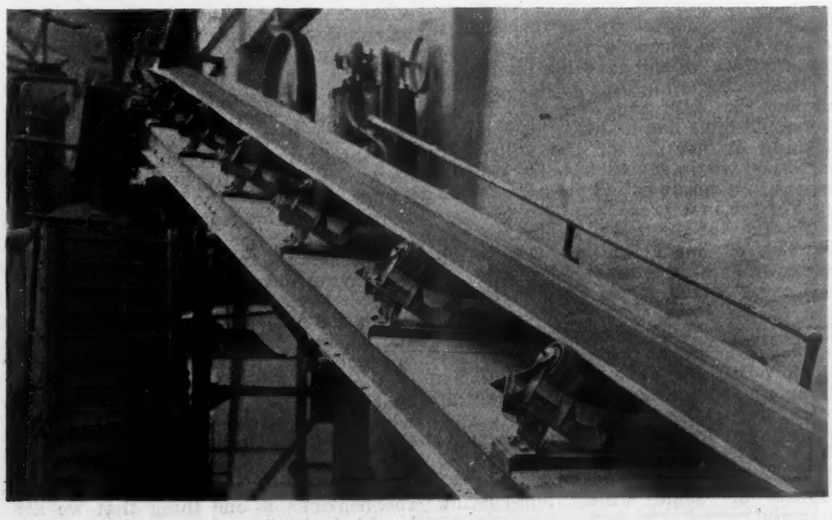
Following the presentation of Mr. Williams's paper, the remainder of the meeting was devoted to a general discussion of ball, roller and sleeve bearings.

In discussing the use of ball bearings in locations subjected to more or less dust and grit, Mr. Spencer of the Western Electric Company, recalled an interesting installation in the buffing and polishing department of that company. In this department, there are in use 50 double-end polishers equipped with ball-bearing, direct-current motors ranging in size from 2½ to 10 hp. The bearings used are of the self-aligning type and Mr. Spencer stated that so far as he knew they had had no trouble with them.

Mr. Spencer stated further: "I find that a great many machine designers are not particular enough about the location of oil grooves and the shape of them. Sharp-edged oil grooves defeat their purpose by scraping off the lubrication. On our drawings in the past, we have allowed or specified a running fit for bearings. In the future, however, we are intending to abandon this idea and will specify a definite clearance, as we consider that this is extremely important in a new bearing. I think that the initial clearance, the kind of lubricant, the method of lubricating the units, pressure, the speed of the journal, together with the alignment, are factors which are very important, in fact, as important as the materials of which the journal and bearings are made. They are very often neglected in machine design.

Ball and roller bearings find extensive application to the rollers of belt conveyors.

Reduced maintenance is said to be the principal advantage obtained in such an application. Strom ball bearings are used in this application.



"We have at the Western Electric Company, probably hundreds of thousands of bearings. I think that approximately half are sleeve bearings and the other half ball bearings. The question arises constantly as to which bearing is the best for our purpose. With the highest speeds, as on some of our wire insulating machines, the ball bearings are used in the mounting of the spindles, while the main drive and intermediate shafts are usually mounted in bronze bearings."

Mr. Brown, of the Westinghouse Electric & Mfg. Company, pointed out that ball bearings, because of their extreme sensitiveness to abrasive material, such as dust, as found in cement plants, have from the first been very carefully enclosed, because of the fact that their life depended upon the enclosure. He said that these enclosures have resulted in retaining the lubricant, which is one of the great points in bearings and from the lack of which sleeve bearings have suffered.

On the other hand, in his opinion, sleeve bearings because they are not as susceptible to abrasive material and because a measure of success can be attained even with poorly designed enclosures, have been neglected to this extent and have given to the ball bearing its point of greatest argument for the position which the ball bearing strives to attain.

Mr. Brown felt that before sleeve bearings were given up for a given application, something further ought to be done in the way of securing a sleeve bearing which will accomplish the results desired. He thought that if the enclosures of sleeve bearings were designed in as systematic and painstaking a way as has been done with ball bearings, perhaps it will be found that the sleeve bearings can be retained and also the many advantages which are inherent in this type of bearing and which must be abandoned by the use of ball bearings.

Mr. Brown also spoke of the oil film which is found in sleeve bearings. He said: "This is one of the very important features of sleeve bearings, which must be abandoned in ball and roller bearings. The oil film is not, as we have heard, a delicate affair, but is an exceedingly strong film which can support great weight. The ordinary pressures in sleeve bearings are on the order of 50 lb. per sq. in. in moderate-speed bearings. The pressure which is necessary to force out the oil film and bring the metal of the bearing into contact with that of the journal is many times greater than this. The shock loads, therefore, provided for by the oil film are very great, and we should think twice before we abandon such an advantage as this.

"I am glad that the ball bearing and the roller bearing have come, because there are many applications where the sleeve bearing has heretofore been used where it is hardly suitable, and where we will find that the ball and roller bearing will be more suitable. Therefore, we should use it in order to obtain the best engineering design."

The fact that the starting friction for ball and roller bearings is low was commented on by several speakers. An example was quoted of motor-driven, mine fans in which the size of the motor had been considerably reduced, due to the fact that the heavy load could be started much easier on ball or roller bearings than on plain bearings.

Mr. Williams said that overloading motors from starting friction is a common occurrence. He spoke of trouble in getting under way a lineshaft which drove Cleveland automatics. The Cleveland automatic is a very heavy machine and uses a clutch instead of a loose pulley. The lineshaft was quite long and was driven by a 50-hp. motor. The entire lineshaft and countershafts had to be set in motion and, consequently, considerable starting torque would be required. Mr. Williams said that when large enough fuses were put on the motor to permit sufficient current for starting the lineshaft, the motor had absolutely no protection against overloading under ordinary conditions.

Another speaker discussed some interesting results of a test made on the street car system at Shanghai, China. These tests again show that in certain applications static friction is decidedly a factor in determining the amount of power consumed. In these tests a street car equipped with ordinary bearings was run through a route, at a certain speed and making the usual stops. This car was then equipped with ball bearings and run over the same route at the same speed and making the same stops. It was found that a saving of 25 per cent was obtained through the use of these bearings. Large ball bearings of Swiss manufacture were used.

In continuing the discussion, Mr. Maxwell said that the static friction referred to was the static friction of the load rather than the static friction of the motors. He said: "The friction of a motor with plain bearings is rather insignificant at starting. It amounts to approximately 15 per cent of the full-load torque of the motor. As far as I know this has never been a point of much importance in the motor. Generally speaking, for motor application the starting torque required to overcome the friction of a sleeve bearing is not a matter of importance in the motor itself."

The question was asked as to whether ball and roller bearings are not somewhat uneconomical for the lighter loads and entirely unsuitable for the higher loads where the centrifugal force in the bearings tends to set up greater friction than in the ordinary sleeve type of bearing. In replying to this question, Mr. Hillman said that he had not found it so in experiments which he had conducted. He said: "Ball bearings that run at 15,000 r.p.m. have worked out very satisfactorily and I imagine that if the friction loss in this case was a very great factor, that we would have had difficulty. If the centrifugal force of these balls against the outer race was very great, we would have had a sliding action and burning or heating of the balls, the same as we have when balls become locked in a retainer and spin around as part of the inner race."

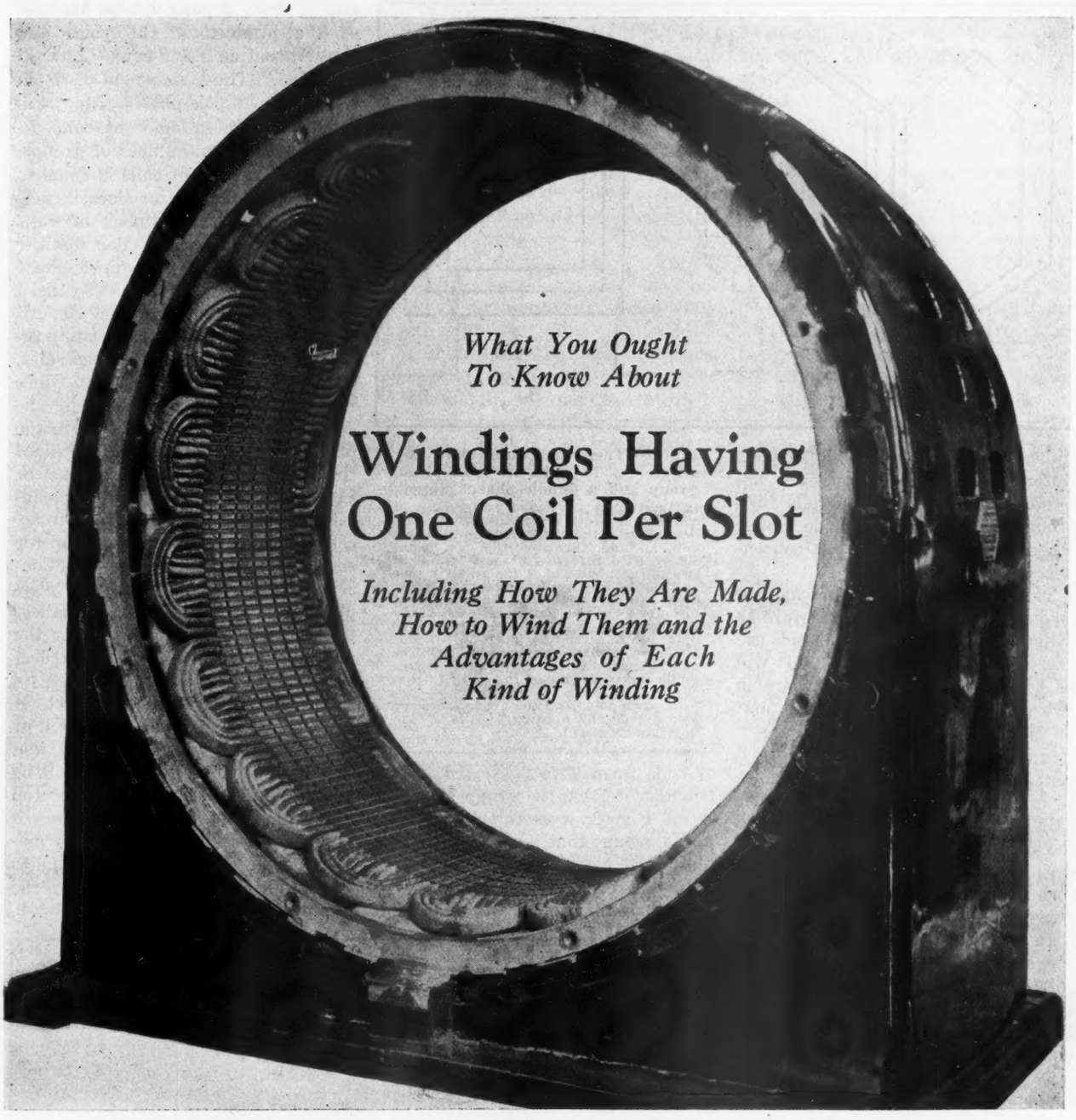
Mr. Bley of the bridge department of the City of Chicago raised the question as to what kind of material to use for a bearing which would reduce friction and at the same time be non-rusting. The bearings he had in mind were to be located on a bridge where they would be subject to drippings and to a damp atmosphere and would remain at rest for so long a time that the rust enemy would probably be the one to be the most dreaded. He desired to know if there was a ball bearing made of bronze or some other non-rusting material.

In answering this question, Mr. Williams spoke of an inquiry from an electrical company that desired to use switches out in a marsh where little attention is likely to be given to them and where there is little chance that they will go through without rusting. He said that they had been experimenting with stainless steel to be used in the bearings for the switches. He found that stainless steel would give a hardness that was just under file-hard, and thought that this would be hard enough to give a bearing with a reasonably large capacity and one that would be assured of long life under very severe conditions. He thought that stainless steel offered more possibilities on a roller bearing than on a ball bearing because of the greater contact of the roller on the race than of a ball on its race, which would mean that for the same size bearing a greater load could be carried with less stress at the point of contact.

Mr. Hillman said that there had been some experiments conducted with races and balls made of monel metal or a composition metal which does not easily rust. These were conducted in Sweden and were not satisfactory as bearings so constructed were unable to carry heavy loads.

Trouble arising over the lubrication of ball bearings was another point considered in the discussion. An example was cited of a 2-hp. motor equipped with ball bearings that were entirely enclosed by a casing with felt rings on the side. This motor was running without undue rise in temperature until too much oil was poured in, when the bearing became smoking hot, due to the fact, in the opinion of the speaker, that the balls splashed the oil around and the felt rings on the outside kept the air from circulating. A scheme of maintaining the oil level just at the lower edge of the balls of the bearing was then devised, so that there would be no splashing and yet sufficient lubrication would be provided. With this scheme, the bearing worked perfectly. It was also found that in this particular case the heat generated by the felt washers on the casing of the bearing was considerable, and by taking these out and adjusting them so that they exerted only a light pressure on the shaft, considerable heating was eliminated.

The question was brought up as to whether ball bearings should be run without oil and as to whether they can be run dry for a very long period without undue wear. In answering this question, Mr. Hillman said: "Running bearings dry is a test that was used some years ago, and was called the dry test. It was thought that one of the things necessary for a bearing to do was to be able to run without oil for a period of time. The Bureau of Standards in Washington has made some tests to determine whether the friction in ball or roller bearings is lessened by leaving out the oil. They have reported that they did not find any difference and this has been interpreted as meaning that ball bearings could run without oil. This is not true at higher speeds, although we have an application that ran for 900 hours at 15,000 r.p.m., where only one drop of oil was given to the bearings every hour. The point that has been mentioned regarding fluid friction of a lubricant heating up the bearings is one thing that we are troubled with."



What You Ought To Know About

Windings Having One Coil Per Slot

Including How They Are Made, How to Wind Them and the Advantages of Each Kind of Winding

By A. C. ROE

Renewal Parts Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

A WINDING having only one coil side in each slot is known as a one-coil-per-slot winding. Such a winding would, of necessity, be single-layer in the slot section, inasmuch as the slots can contain only one layer of coils. The coil ends, however, may be arranged in two or more layers. One-coil-per-slot windings are used principally on the older types of high-voltage machines.

The most common type of one-coil-per-slot winding is the concentric chain winding. This winding derives its name from the fact that the coils in a group are arranged concentrically with respect to each other, that is, one coil fits inside of the other, and where the coil ends overlap, the arrangement gives the appearance of the links in a chain.

A WINDING having only one coil side in a slot is known as a one-coil-per-slot winding. Of necessity, it must be single-layer in the slot section. The coil ends of the winding may take several different forms: concentric chain, basket, diamond, and involute types being typical. All of these types are described and details for laying them out are given in this article. A succeeding article will treat one-bar-per-slot windings as used on turbo-generators.

Fig. 1—This is a concentric chain winding used on a 400-hp., 6,000-volt, three-phase induction motor.

In Fig. 1 is shown a concentric chain winding for a 400-hp., 6,000-volt, 300-r.p.m., 24-pole, three-phase, 60-cycle, induction motor. The stator has 216 slots and since one coil occupies two slots, there will be 108 coils. As it is a three-phase machine, it will have 36 coils per phase and since there are 24 poles in the ma-

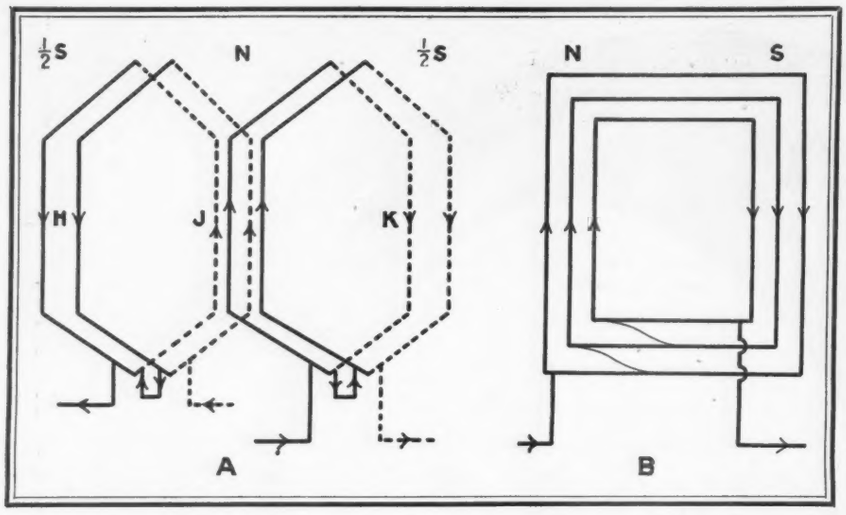


Fig. 2—These diagrams show the difference between a pole-phase group and a dupole-phase group.
In diagram *A* are shown two groups of coils for a two-layer winding. As will be noticed, the two bottom (shown dotted) and the two top coil sides shown at *J* form a full pole while the two top coil sides at *H* form half a pole and the two bottom coil sides at *K* also form half a pole. Hence the two groups of coils form two poles and each group is known as a pole-phase group. In diagram *B* is shown a group of coils for a concentric chain winding. The coil sides at the left form a north pole while the coil sides at the right form a south pole; hence the one group of coils forms two poles and the group is known as a dupole-phase group, that is, a two-pole phase group.

chine, it will have nine slots per pole. Notice how the coil ends are arranged. There are three coils in a group, one coil falling inside of the other; that is, the coils are concentric.

This winding is wound in what are termed two ranges. This refers to the manner in which the coil ends are arranged to pass each other. It will be noticed that the coil ends are in two planes in Fig. 1, and that half of the coils come out of the slot straight, are given a radius, and bent back into the core at a distance of one pole pitch away. The other half of the coils is bent down and the plane of the coil is changed 90 deg. before it is bent back into the core at a distance of one pole pitch away.

In this type of winding, the coils are arranged so that each group of coils forms two poles; that is, it is known as a consequent-pole winding. Hence, there will be one-half as many groups as in a two-layer winding. This is shown in Fig. 2. In diagram *A*, are shown two groups of coils for a two-layer winding. These two groups form two poles; the four coil sides at the center form one pole, the two coil sides at the left form half a pole, and the two coil sides at the right form half a pole. Thus the two groups form two poles and each group is known as a pole-phase group. In diagram *B* is shown one group of coils of a concentric chain, single-layer winding. The three coil sides at the left form a north pole, while the three coil sides at the right form a south pole. Hence, this group of coils forms two poles and to distinguish it from the group shown at *A*, of Fig. 2, it is called a dupole-phase group; that is, it is a two-pole phase group.

In the concentric chain winding previously mentioned, the number of dupole-phase groups will be one-half of the product of the poles and phases; that is, it will equal $(24 \times 3) \div 2 = 36$. The number of coils in series per dupole-phase group will equal the total number of coils divided by the total number of groups. The total number of coils is equal to one-half the number of slots; hence, in this case, the number of coils equals $216 \div 2 = 108$. The number of coils in series per dupole-phase group will equal $108 \div 36 = 3$ coils.

As has been explained, one concentric group of coils will form two pole-phase groups which, of necessity, must belong to the same phase. Since the pole-phase groups fall in the order of the phases as shown in the top diagram in Fig. 3, and since there are three phases, there must be slots enough left inside of the smallest coil of the concentric group to accommodate one pole-phase group for each of the other two phases. Consequently there must be two pole-phase groups inside of the smallest coil of a concentric group. For the winding shown in Fig. 1 the smallest coil must leave six slots between its two sides. Therefore, the pitch of this coil will be 1-and-8; the pitch of the middle coil will be 1-and-10, and the pitch of the outside coil will be 1-and-12. This is shown in the top diagram of Fig. 3.

A two-layer winding for this machine would have a coil pitch equal to the number of coils divided by the number of poles; then $216 \div 24 = 9$,

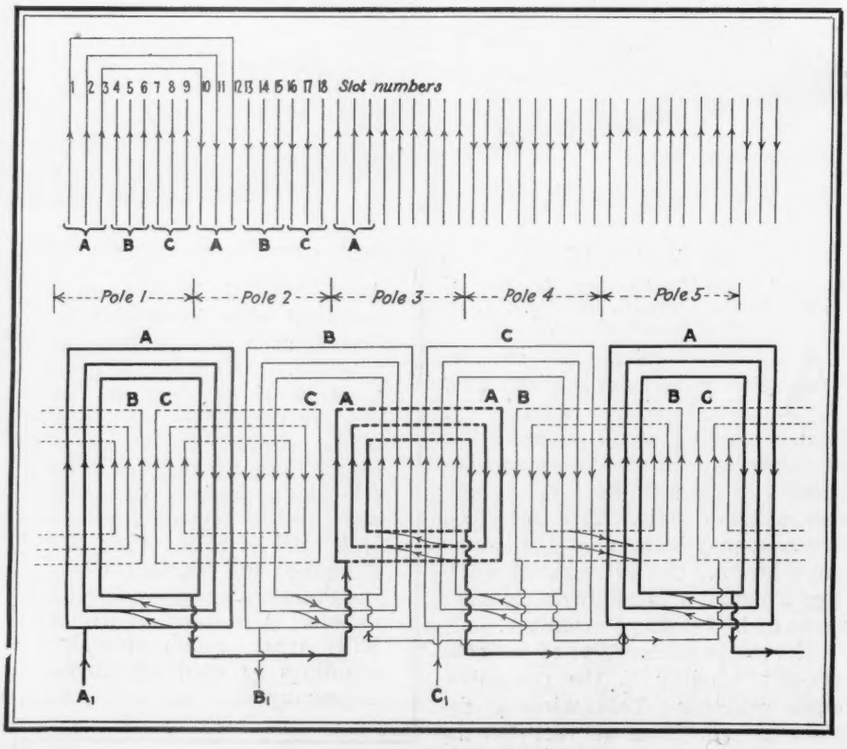


Fig. 3—Here is the connection diagram for the concentric chain winding shown in Fig. 1.
This winding is two-range, as can be seen from the two shapes of coils that are used.

or a pitch of 1-and-10. This is 100 per cent pitch. Consequently, since the middle coil of the concentric chain winding has a pitch of 1-and-10, it has full or 100 per cent pitch; the inside coil is chorded one slot under-pitch and the outside coil is chorded one slot over-pitch. The chord factor, however, of both the inside and outside coils will be the same, for the average pitch is $(7+9+11) \div 3 = 27 \div 3 = 9$, or a pitch of 1-and-10.

In laying out a winding similar to the one shown in Fig. 1, lay out slots enough for, say, five poles, as shown in the top diagram of Fig. 3 and mark the arrows on each pole group so that the polarity of each pole group will alternate, as shown. Since we know the pitch of the coils, we may draw in the first concentric group of A-phase coils, as shown in the diagram. We will take the first pole-phase group of each pole, shown at the left in both diagrams in Fig. 3 as having coils that come straight out of the slot and are not bent down. The outside coil will be the start of the A phase, as shown at A_1.

Slots *4*, *5* and *6* will be occupied by the B phase and slots *7*, *8* and *9* will be occupied by the C phase. Knowing the pitches of all of the coils, the coils may be sketched in the order shown in Fig. 3. Since slots *1*, *2*, *3*, *10*, *11* and *12* are occupied by straight-out coils, slots *4*, *5*, *6*, *7*, *8* and *9* must be occupied by bent-down coils; that is, coils of the second range. From the diagram you will notice that the straight-out coils fall in the order A, B, C. The same is also true of the bent-down coils.

We have started the A phase at A_1. We may start the B phase in the next pole at B_1 and the C phase in the third pole at C_1. This will give us two phases with current leading into the winding and one phase with current leading out as is shown by the arrows on the leads in Fig. 3. This is the two-in-and-one-out check which all three-phase developed windings must meet.

In connecting the individual coils, the outside coil should be connected to the middle coil, the middle coil to the inside coil, and the inside coil is then connected to the outside coil of the next dupole-phase group for that phase.

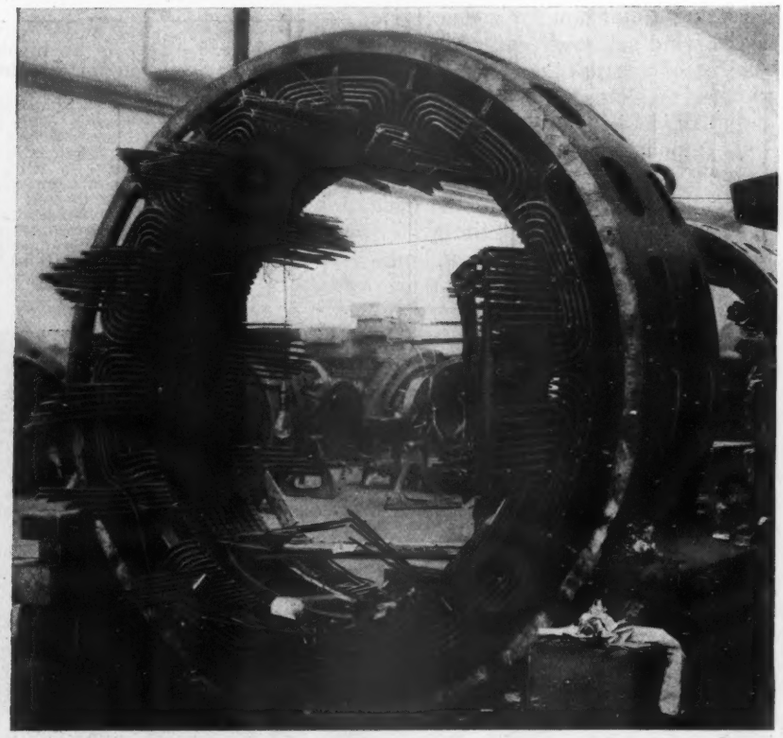
With concentric chain windings having an odd number of groups, it is necesary to use a specially-shaped group of coils. Take the case shown in Fig. 5. This is a three-phase, 14-pole stator, having 210 slots and 105 coils. This winding has 15 slots per pole and, $(14 \times 3) \div 2 = 21$ dupole-phase groups. There will be $105 \div 21 = 5$ coils per dupole-phase group. Hence, the pitch of the inside coil of a concentric group of coils will be 1-and-12. In Fig. 5 there are twenty concentric groups of coils in place. Ten of these groups are made up of coils having bent-down ends and ten having ends which are in the same plane as the coil sides. At the lower left of Fig. 5 there are two places where five slots have been left empty. Coils having coil ends in the same plane as the coil sides cannot be used here as they would obstruct the unconnected coil group falling between the two sets of empty slots. Coils having bent-down ends, the same as the others, could not be used, for they would obstruct the adjacent, bent-down group of coils. Hence, to fill these slots, coils having specially-shaped ends must be used.

The winding shown in Fig. 5 is termed a "shoved-through" type, two-range, concentric chain winding. Five different sizes of molds are required for this winding. Ten groups are shoved through from one side of the stator and ten groups from the opposite side. The free ends are then formed and connected together on the stator, as shown in the lower part of Fig. 5.

The only advantage of this type

Figs. 4 and 5—Diamond-shape winding and shoved-through type concentric chain winding.

The winding shown on the left is for three-phase service and has 16 poles, 144 slots, 12 coils, with three coils per dupole-phase group. Each group of nine coils shown forms two poles. The machine on the right has a shoved-through concentric chain winding. The coils are shoved through from one side of the stator and the free ends formed and connected as shown in the lower part of the illustration. This machine is three phase and has 14 poles, 210 slots, 105 coils and 21 dupole-phase groups. A special or bastard group is to be placed in the empty slots in the lower left of the illustration.



of winding is that it can be well insulated on the ends. This, however, is more than offset by the expense involved in making the number of different sizes of molds required for winding the coils and by the labor required in placing the coils in the stator and connecting them up. Another disadvantage is that this type of winding cannot be readily adapted to changes in the number of poles or phases.

For example, take the case shown in Fig. 6, which is a three-phase stator having 96 slots, 16 poles, 24 dupole-phase groups of two coils per group, and two slots per pole per phase. If we wanted to use this frame for a 12-pole winding, it would necessitate leaving a few slots idle, as there would be $(12 \times 3) \div 2 = 18$ dupole-phase groups and with 48 coils there would be $48 \div 18$ groups, which gives us 12 groups of three coils and six groups of two coils. Odd grouping cannot be used, however, and therefore it would mean killing 12 coils. This is a loss of 25 per cent and consequently the 12-pole winding would not fit. Again, assume that we desired to use this stator for a two-phase 14-pole winding. There would be $(14 \times 2) \div 2 = 14$ dupole-phase groups. Dividing 48 by 14 gives us 14 groups of three coils with six coils left over. Hence we would have six dead coils. Here again this change could not be satisfactorily made.

From the above it follows that to construct a diagram for a concentric chain winding, first, determine the number of groups; then calculate the number of slots per pole per phase, and finally find the number of ranges. Next lay out about four or five poles as is shown in Fig. 3, place arrows on the coils so as to form the pole groups and then connect the groups together using the two-in-and-one-out method mentioned before.

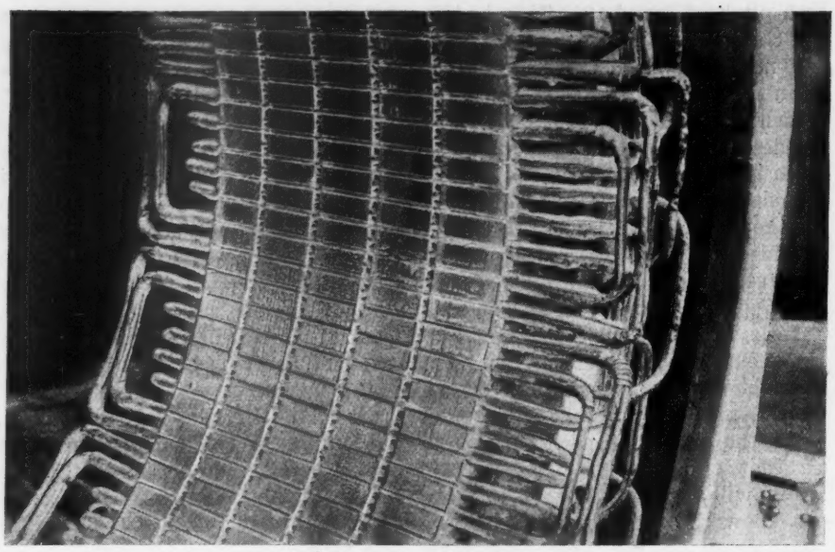
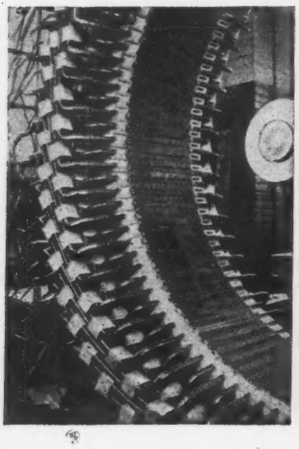


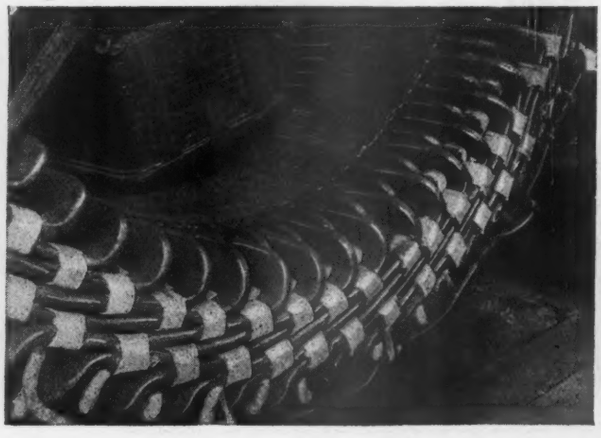
Fig. 6—Here is another shoved-through type of concentric chain winding.
The advantage of this winding is that it can be well insulated on the ends.

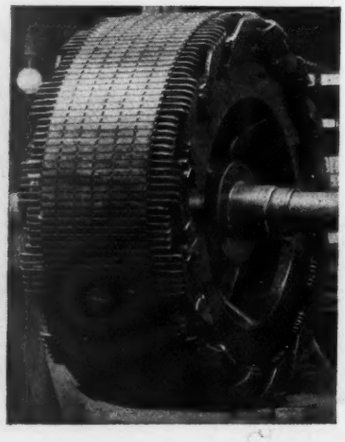
Another form of one-coil-per-slot winding is called the basket winding. In this winding the coils are all of the same size and are shaped while winding. The coil ends cross each other by the most direct route in smooth regular curves. The interweaving of the coil ends gives the winding an appearance similar to the weave of a basket, hence the name.

Still another form of one-coil-per-slot winding is the diamond-shape type shown in Fig. 4. This winding has 144 slots, 72 coils, 16 poles and is intended for three-phase service. The winding is wound with consequent poles; hence each group of coils forms two poles as has been explained previously in this article. It will be noticed that the coil sides which connect to the ends on top form one pole and the opposite sides of the same coils which connect to coil ends overlapped by the above mentioned coil ends, form another pole. In other words, each group of nine coils forms two poles; consequently, there will be three coils per dupole-phase group. The coil pitch depends upon the number of slots per pole.

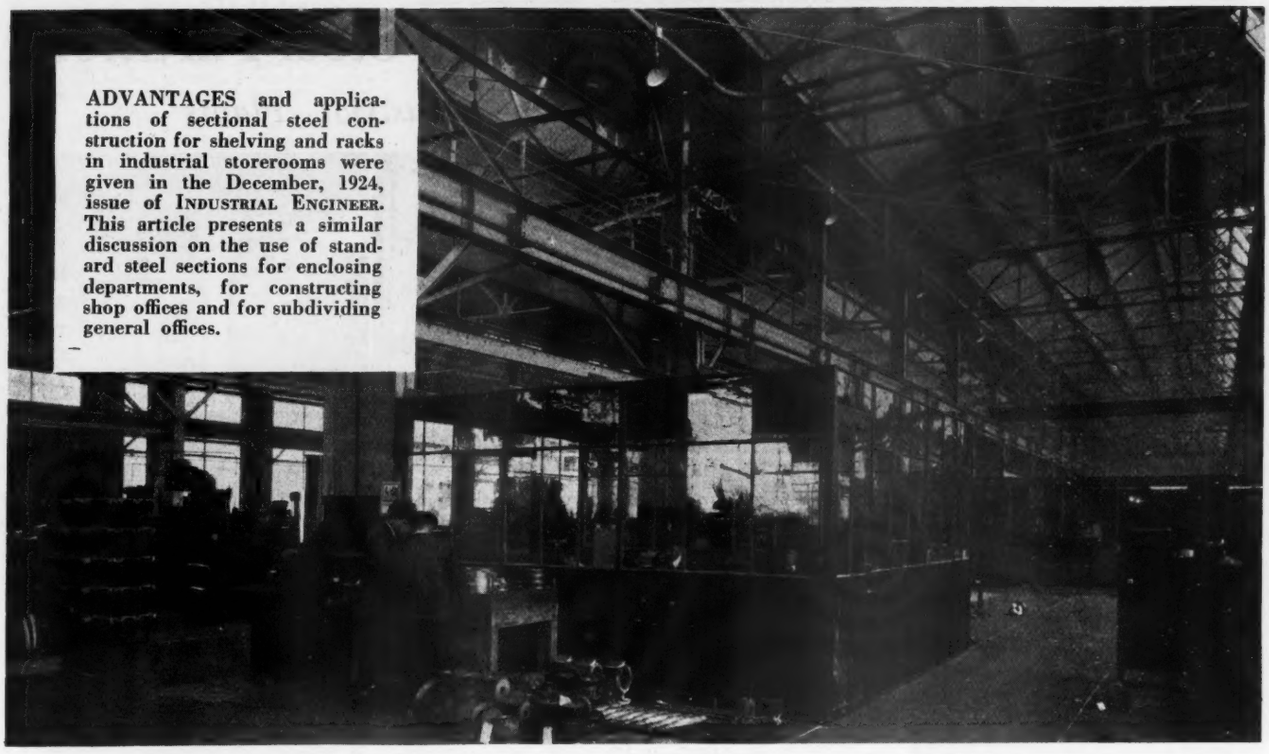
The advantages of the diamond-shape coil are as follows: A form may be made so that it can readily be adjusted for different sizes of coils; the coils can be easily insulated and assembled; repairs to damaged windings can be made with small expense; the winding can be arranged and connected in nearly any manner; the connection may be readily changed to suit different conditions; for a certain machine the coils may be alike. (*Continued on page 47*)







Figs. 7 to 9—Here is an involute type of one-coil-per-slot winding.
Fig. 7 shows an involute winding in place ready to connect. Fig. 8 shows the winding stubbed and connected. Fig. 9 shows an involute winding for the rotor of a large induction motor. This rotor has 90 slots, 45 coils, 10 poles, with 15 dupole-phase groups of three coils each. Notice that in all of the illustrations, one coil side is shorter than the other for the same coil. As can be seen the short bar connects to the bottom coil end and the long bar connects to the top or overlapping coil end.



ADVANTAGES and applications of sectional steel construction for shelving and racks in industrial storerooms were given in the December, 1924, issue of INDUSTRIAL ENGINEER. This article presents a similar discussion on the use of standard steel sections for enclosing departments, for constructing shop offices and for subdividing general offices.

This factory office is adopted as standard in this plant. Here it is located under a craneway and so is roofed over for the sake of safety.

Some Details On the Use of

Industrial Partitions in Office and Factory

For Erecting Enclosures Around Departments and for Isolated Offices, Such as for Foremen and Timekeepers, as Well as for Subdividing Large Areas into Offices or Small Rooms

By FRANK E. GOODING
Associate Editor, Industrial Engineer

MODERN industrial plants are under an intermittent process of making changes and rearrangements in layout. Fluctuating production demand, new or discontinued products, or changes in methods or processes, cause increases or decreases in the space required and in many cases an entire shifting of machines and sometimes of whole departments.

Industrial men have found that this occurs so frequently that it is desirable to use partitions which may be taken apart without damaging them and again erected in a new location. Wood was first used for this purpose, but because of the numerous advantages of steel, as will be pointed out later in this article, a large proportion of these are now made of steel or wire and often provided with glass panels, doors and transoms. Some wooden partitions are made in sectional units but these are generally used in offices and do not stand up under the hard knocks they receive in industrial service. A hard bump with a loaded truck would crush them. Also, in most industrial works it is desired to have as little wooden construction out in the plant as possible because it adds to the fire hazard. This hazard is increased due to the possibility of oily waste or rags being accidentally left in contact with the wooden partition.

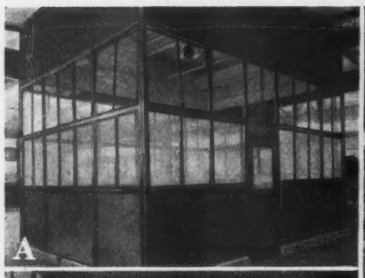
Steel partitions have many of the same advantages given for steel in the construction of factory shelving, as indicated in the article on, "Shelves and Racks in Industrial Storerooms," which appeared in the December, 1924, issue of INDUSTRIAL ENGINEER. One of the first and most important advantages of steel construction for partitions is its ability to resist fire. Steel is not only noncombustible but it will often retain a fire in a closed office until it has burned itself out. Also, where sprinklers are installed, all fire and water damage is confined to the one location. Where the building has a sprinkler system at least one sprinkler-head is required in each enclosure. Steel partitions will not absorb oil, turpentine or paint as will wood and so do not become hazardous.

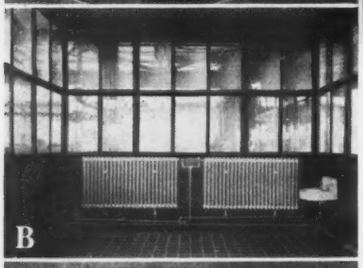
Perhaps the next most important advantage of steel lies in the possibility of unit construction which enables whole sections to be assembled with doors, glass or wire panels, or transoms as desired. This unit construction enables the partition to be salvaged by taking it apart and using it again when necessary to make any rearrangement. Also, these units can be fitted together to fill almost any opening.

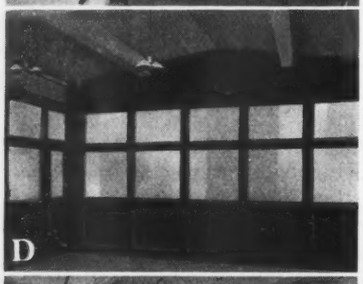
Another advantage is that steel is

Typical Applications of Standard Steel Partitions

Examples Taken from Thirteen Industrial Plants







A and B—Exterior and interior views of the standard mill offices used at the Lorain, Ohio, plant of the National Tube Co.

C—Notice how the standard units fit around a column and pilaster cap. The large glass area in the partition units gives considerable light through a double row of offices.

D—The space between tops of partitions and irregular-shaped ceilings is filled in with special plates.

E—Wire mesh partitions may be used as backs to shelving in order to let more light through. Note the cross bracing necessary when backs are omitted.

F—A neat arrangement of individual offices made from standard units.

G—This industrial recreation room is built up of standard steel-and-glass units.

H—The wire mesh partitions around the stockroom permit the same heating and ventilating units to heat both stockroom and factory.

I—Note here the sliding door, the receiving wicket and also the swinging floor opening for receiving or issuing tote boxes.

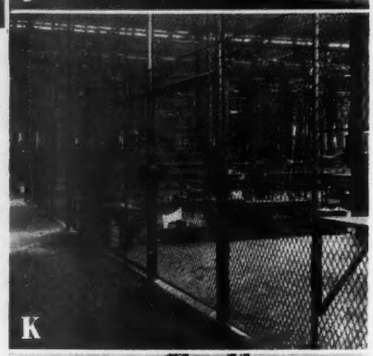
J—A neat method of fitting the partitions around the flaring top of the column. The double door may be obtained in most types of standard equipment.

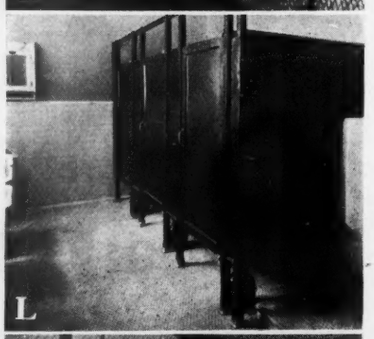
K—Another wire-mesh-enclosed stockroom with several subdivisions.

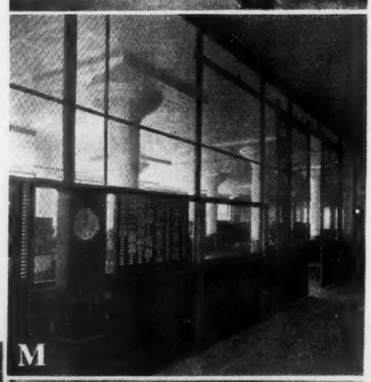
L—Special rustproof partitions used in factory toilets. Similar partitions are sometimes used around showers. Standard steel units are used for the enclosing walls.

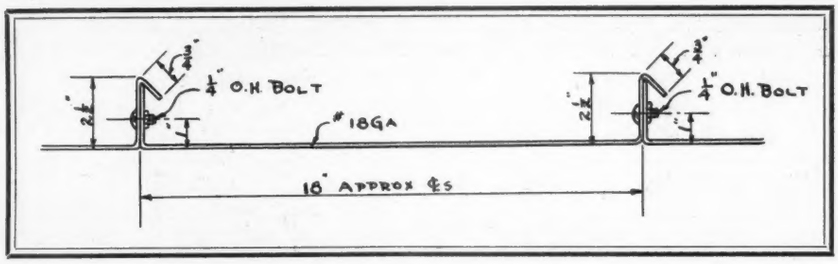
M—Here a combination of steel units and wire mesh is used. Notice also the large double sliding doorway.

N—This application of wire mesh units closes off a stairway.









How small offices are roofed over.
This is one type of standard steel section used for roofing over small offices. These do not need any support except at the end when standard steel sections are used, unless the office is wider than 10 ft. If glass in units is used, the permissible width between supports is 8 ft. Frequently it is possible to support the roof from the ceiling of the main building, as is shown in the two illustrations at the bottom of the page.

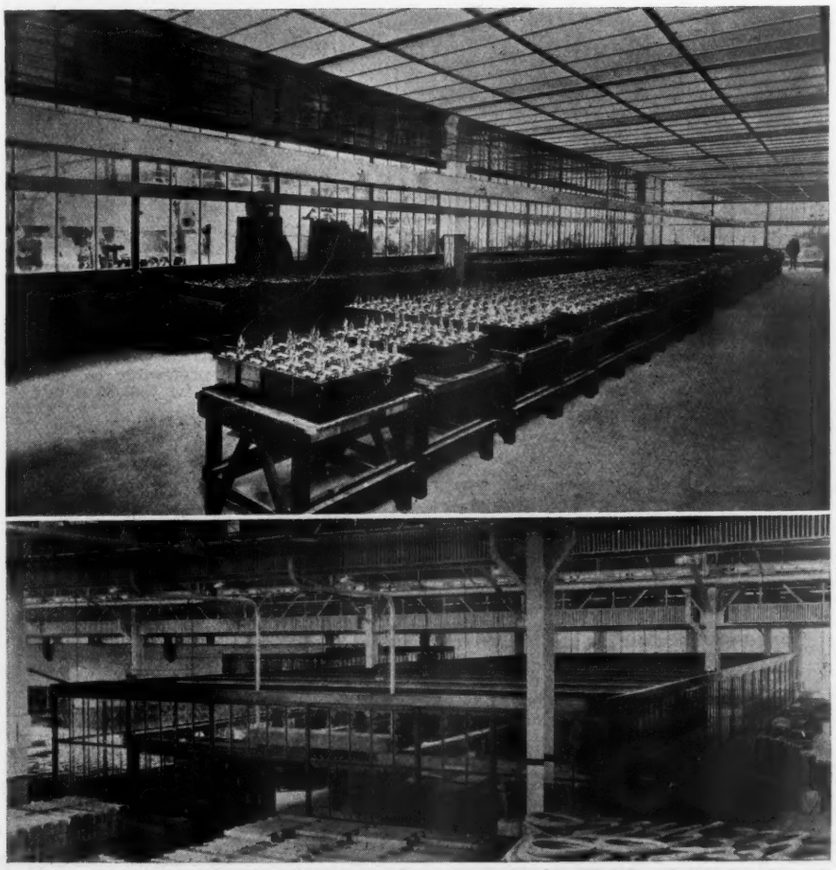
easily painted or enameled and carries a good finish. Some of the manufacturers of these partitions supply them with only a priming coat for protection during shipment and the user paints them any color desired. Others supply them in a more highly finished enameled coating. Also, steel is easy to clean and keep clean. Its strength is an important consideration when used in an industrial plant, for although a partition may be sprung when bumped, as by a loaded truck, any permanent indentation may be straightened out for the sake of appearance. These bumps may interfere somewhat with dismantling but they could be straightened out again before reassembling.

Modern factory buildings are often erected with large, open floor areas. Frequently, no actual division walls are placed between departments. A large open area is usually easier to heat and ventilate than are smaller subdivisions. In addition, it would hardly be practical to build in many permanent walls because of the difficulty in deciding exactly where they should be. This has led to the wider use of steel unit partitions.

These are used for three general purposes: (1) Foreman's or timekeeper's factory offices; (2) Subdividing main factory or general offices; (3) Separating departments, such as enclosing stockroom, toolroom and similar places.

Since management has begun to exercise more careful control and supervision over the workers and their jobs, it has become necessary to maintain larger departmental offices distributed about the plant. These are for the foremen, timekeepers and also for handling the assignment of jobs to workers. Unit steel sections are easily adaptable for this purpose, as is shown in the illustration at the head of this article. Here the door unit is the same size as a wall section and so can be inserted anywhere in the wall. Also, here, as in many other cases, it is necessary to cover the office to keep out dirt and noise and also make it easier to heat for the benefit of those who must remain inside all the time and so require a higher temperature than the factory workers who are more active. Very frequently, a few girls are employed in these offices. In such cases, more adequate provision for heating is necessary. Ordinarily, steam is used if available. However, many warehouses are not heated. In such cases, a small office such as this may be most economically heated by unit electric heaters, as electrical energy can be carried any reasonable distance with practically no loss and at much less installation expense than for a steam unit. Lines carrying steam several hundred feet, as is sometimes necessary, would have a larger loss in the radiation of the line than would be required to heat the office.

Frequently, it is desirable to add some facility for ventilating the shop offices which are covered over. This is not always done, however. One way to do this is by the use of transoms or upper sashes which may be opened. These, however, open up the enclosure to noise and dirt. Another way is to use a fan ventilator set in a panel or a small blower to exhaust the air from the room. Often it is not necessary for the office to be covered over. However, when under a craneway, as in the illustration at the head of this article, it is much better from a safety standpoint to cover it. Many manufacturers of partitions will provide unit sections of metal or glass, or in combination,



A large room is constructed of standard steel units and roofed over.
This battery room is erected inside a branch factory of a large automobile manufacturer. Here it was necessary to roof the enclosure. This was done by using standard steel sections and some glass sections, which enabled the room to be lighted by "borrowed" light from the skylight of the main building. These glass sections are suspended from the ceiling of the main building.

which may be used as a roof. In buildings with low ceilings, the partitions may be extended clear up to the ceiling. After the partition units are run up to the full height the space between the top rail and the ceiling is filled with a special plate which may be cut to fit around cornices, columns or beam ceilings.

Steel partitions are becoming more commonly used in laying out general or factory offices in connection with industrial plants because alterations are perhaps more frequent in office layouts than in the plant itself.

Several arrangements of these steel partitions for offices are shown in some of the accompanying illustrations. In buildings with ceilings of ordinary height the partitions often are extended to the ceiling. However, they are frequently stopped about a foot or two below the ceiling so as to provide for ventilation. At this height, the partitions do not allow voices to carry over objectionably from adjoining offices. Where partitions do not reach the ceiling, a special cornice or head rail in long lengths is used on the top. With these lateral or ceiling braces are usually not necessary unless a wall extends over 20 ft. in length.

Although it is not always necessary to separate or enclose departments, it is very desirable at times, as in the case of toolrooms, stockrooms, experimental or new development departments, and laboratories, plating rooms or other departments which give off fumes or odors. Some of these need tight enclosures while with others the partitions need not extend to the ceiling. In some cases, it is even more desirable to have a partition of wire mesh above the lower panel to aid ventilation and the distribution of heat. Also, in some cases wire partitions are used to aid in the distribution of light. A steel mesh can be obtained in place of glass panels in almost any type of partition. Mesh is also used around tool and other supply wickets. Each manufacturer of steel partitions offers various types of wickets, some of which are shown in the accompanying illustrations.

Laboratories and similar departments producing fumes or odors are usually in rooms with low ceilings. The partitions can then be extended all the way up. However, when it is necessary to place them in large, open rooms with high ceilings the enclosure must be roofed over. How this is done in the battery room of a branch factory of a large automobile manufacturer is shown in the illustrations and sketch shown on the previous page. This is an exceptionally large room and the side walls were erected complete from a standard partition unit.

The roof was assembled partly from glass units and the balance of steel. The entire room is clear of posts or uprights. For assembling the roof lightweight steel beams or supporting bars extending across the roof were anchored into the partition posts and were held up by support bar hangers suspended from the roof of the main building. The glass panels in the roof of this battery room enable advantage to be taken of the natural illumination received through the skylight of the building. If it should become necessary at any time to change this battery room, it can be taken down and re-erected in some other part of the plant, or even in another plant without any additional cost except labor cost.

The method of constructing a roof for a smaller shop office is shown in the accompanying sketch. In the assemblage of the steel roof as shown in the detail sketch, sheets are cut approximately 18 in. wide and are curved up, lapped over and bolted together with ¼-in. bolts. This construction is strong and sturdy and can be used without support bars of any kind up to a width of 10 ft. This, of course, holds good for any length of room. However, roofs which are assembled from standard glass units can be constructed without support bars of any kind up to a width of 8 ft. In shop offices of larger size where the roof cannot be self supporting, this roof surface may be supported from the ceiling with hanger rods, as is indicated from the illustration of the large battery room.

In erecting partitions the main requisite is to follow the directions of the manufacturer and to be sure that sections are vertical, that the floor is level, or that the partitions are blocked up so that they fit together securely both horizontally and vertically and that they are fastened together properly. Otherwise, due to improper construction and forcing these sections together, some section may be put under a strain which may interfere with dismantling them; also if they are strained (*Continued on page 46*)

Information Necessary When Planning or Laying Out Steel Partitions

These ten questions, which are used by one manufacturer in preparing estimates, will also be valuable to the prospective user in determining some of the points to consider when planning an installation.

(1) Floor plan showing columns, walls and windows or mullions adjoining partitions, also location of doors in partitions and direction in which they are to swing.
This floor plan must show dimensions, and state whether they are exact or approximate. Often a small change in layout will permit standard units to be used at a considerable saving in cost.

(2) Is the floor wood or masonry?

(3) Nature of walls (brick, plaster, etc.).

(4) Are wall surfaces, into which partitions run, straight or irregular up to the height of the partition head rail?
If irregular, it is usually necessary to place the nearest mullion a short distance from the wall and fill the intervening space with a flanged steel filler plate cut to fit the wall. The same applies to columns.

(5) Is the partition to be open or closed above the head rail? If closed, state exact distance from floor to ceiling.
Partitions that meet the ceiling cost much more to make and fit than when a space (say 1 ft.) is left. This space makes little difference in sound transmitted; it gives clearance for sprinkler pipes, etc., and it is valuable for ventilation.

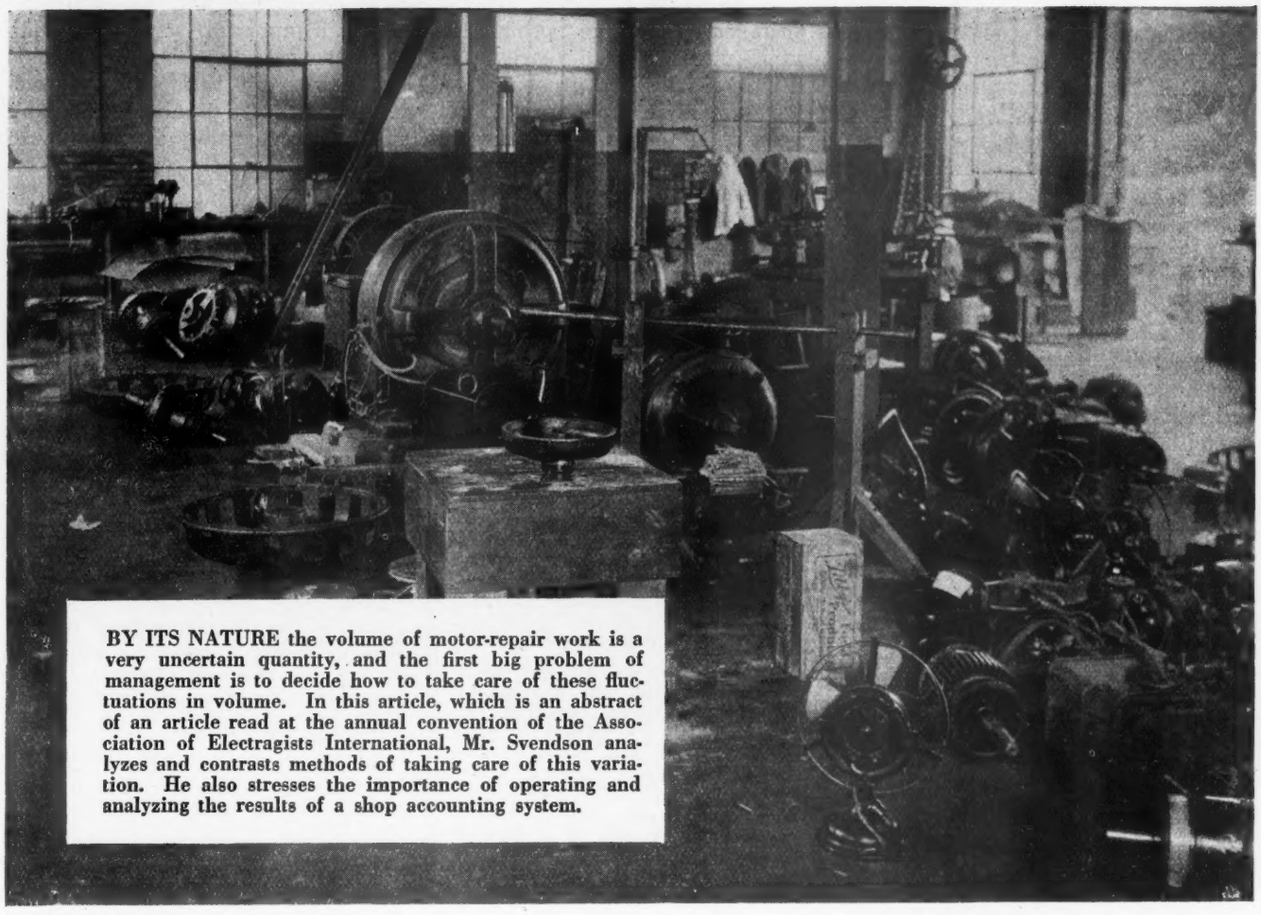
(6) Must partitions meet window mullions?
If so, furnish a sketch of vertical profile, so that a steel plate can be cut to fit the desired contour.

(7) Specify desired height of base plate.
This should preferably be the standard height for that type of partition; but it may be desk height (32 in.), or some other height, at additional cost.

(8) Minimum door opening allowed.
See catalog for standard door openings. Occasionally wider doors are necessary to accommodate furniture or shop articles.

(9) Specify kind of glass desired.
Wire grills or screens will be furnished if specified.

(10) Hardware should be specified in detail.
Standard equipment should always be used. For interior partition doors, locks and latches are usually unnecessary. A door check and pull handle are better. Where hardware is not specified we furnish such doors with hinges and pull handle, but not with door check. Outside doors will be furnished, on specification, with cylinder locks to fit customer's master keys.



BY ITS NATURE the volume of motor-repair work is a very uncertain quantity, and the first big problem of management is to decide how to take care of these fluctuations in volume. In this article, which is an abstract of an article read at the annual convention of the Association of Electragists International, Mr. Svendson analyzes and contrasts methods of taking care of this variation. He also stresses the importance of operating and analyzing the results of a shop accounting system.

One of the best solutions of the variable-volume problem in conducting a repair shop, is to take up the rebuilding of used electrical apparatus. By doing so, an organization can be maintained to give peak repair service at all times, and when the repair work drops off, the same shop crew can be used for overhauling and rewinding used machines.

Business Viewpoints on

Operating and Managing Motor Repair Shops

Together With Ways of Handling a Fluctuating Volume of Work, Importance of Proper Accounting, and Stores Control of Repair Parts

By GEORGE P. SVENDSON
President, Boustead Electric & Mfg. Co., Minneapolis, Minn.

ORIGINALLY, the motor-repair business was operated as a sort of necessary evil in connection with electrical contracting and it is even today considered by many Electragists as an unprofitable branch of their business.

But of late years, the use of electrical power equipment has grown by leaps and bounds and the old type of motor-repair shop has found itself unable to take care of the increased business. This has resulted in a great many establishments devoting a substantial part of their efforts to work of this character.

By its nature the volume of motor-repair business is a very uncertain quantity, and the first big problem of management is to decide how to take care of these ups and downs of volume. They are not seasonable to any great extent, nor can prediction of them be based on past experience since they originate in accident, misfortune and carelessness, which have no rule or law to govern except the law of averages. This law of averages will only help when the territory served is increased and hence points to one way of carrying on an exclusive motor-repair business: namely, *to go after it in a big way and cover a large territory geographically.*

Prompt and efficient service is the foundation of a successful repair shop and with a widely fluctuating volume of business such service cannot be maintained without a working force and equipment based on practically the peak load.

At first thought it would seem that an ideal combination would be to operate the motor-repair shop in connection with the regular electric contracting business. A careful analysis of such a combination shows it to be a poor one at its best. Such combinations, indeed, are responsible for the many statements that the motor-repair business is not profitable.

In the first place the men required for the two classes of work need

entirely different training. Your shop mechanic usually makes a poor wireman and the average journeyman is lost on the simplest rewinding job.

In the office, likewise, the training required is different. The repair-shop office man must be trained along more strictly engineering lines and be well up on electrical and machine design as well as on shop production methods. In addition the equipment and materials used are distinctly different.

Some may dispute the above claim and point to successful firms carrying on both lines of work, but it will usually be found that such firms are either operating with distinct and separate departments, each complete in itself, or one department is suffering at the hands of the other.

One of the best solutions of this variable-volume problem is to take up the rebuilding of used electrical apparatus.

In this way an organization can be maintained to give peak repair service at all times and when the repair work drops off this same shop crew and equipment can be used for overhauling and rewinding used machines. Likewise in the office the switch can be made smoothly and efficiently. There is engineering work in remodeling or changing the design of old machines; there are stock lists and advertising to be looked after and the selling and rental of this equipment is highly profitable.

Of course other lines can be added, such as new motors and control apparatus, with allied supplies, such as pulleys, fuses, belting, shafting, etc., but so far as the shop proper is concerned there is nothing like the rebuilding of used machines to act as a sort of storage battery to consume the surplus productive power of the repair department.

In some cases where plenty of capital is available the rebuilt machines may become the dominating feature of the business, but at any rate the two go hand in hand and make the ideal combination.

On this basis let us briefly consider some of the more important points of general business principles as they apply to a motor-repair shop as outlined in the Electragists' pamphlet by Lawrence W. Davis.

One of the most important of these is accounting. To run a motor-repair shop without an adequate accounting system is simply courting disaster. Above all things use an accounting system after it is installed. There is nothing like making monthly and yearly comparisons of sales and gross and net profits as well as departmental comparisons. It shows the leaks and indicates where and when to put on special effort.

Many interesting and sometimes startling facts can be discovered by comparing various monthly or yearly totals. For example: Shop overhead compared to total productive man-hours; general office overhead compared to number of sale tickets put through; store-room expense compared to number of items handled, etc. Many Electragists put in a system and forget it except to get a final profit-and-loss statement at the end of the year, whereas such a system contains a mint of information that if properly analyzed and used will make for more business and better profits.

IN EMPHASIZING the importance of accounting in motor-repair shops, Mr. Svendson makes the following statements:

"To run a motor-repair shop without an adequate accounting system is simply courting disaster. Above all things use an accounting system after it is installed. There is nothing like making monthly and yearly comparisons of sales, and gross and net profits as well as departmental comparisons. It shows the leaks and indicates where and when to put on special effort.

"Many interesting and sometimes startling facts can be discovered by comparing various monthly or yearly totals. For example: Shop overhead compared to total productive man-hours; general office overhead compared to number of sales tickets put through; store-room expense compared to number of items handled."

In the motor-repair business practically all the work is done on a time and material basis; so it is absolutely essential that overhead be properly charged to each job. A good accounting system is the first step to secure this result.

One important point often overlooked by repair shop men is the proper basis of figuring allowances on old apparatus when taken in trade for new or rebuilt machines.

If an accurate account is to be kept of the profit on rebuilt machines it is essential that some system be installed to keep tab on the value of such stock.

One of the best schemes is to use an individual stock card for each machine, giving its complete technical description and its "trade-in" or "cash purchase" value. In addition, the cost of rebuilding should be shown. In this way an exact inventory record is always available and the cost value of the rebuilt apparatus can be accurately determined.

Without such a system the year's profit-and-loss statement will mean nothing, as the pricing of the rebuilt machine stock will be subject to personal judgment and if priced above the actual cost will show a paper profit which has not been realized and on which taxes will have to be paid. On the other hand if priced below the actual cost, a paper loss will be shown that will be misleading and reflect in disproportionate profits later.

While there is a sort of market selling price on rebuilt apparatus there is no corresponding market cost, as so many variables enter into the matter. Therefore, the only safe procedure to follow is to keep a record of the actual cost.

Where used machines are rebuilt by a repair crew in odd hours between jobs, it is advisable to carry the cost of rebuilding into the inventory without overhead added. Experience will usually show that rebuilding in this manner will cost appreciably more than where the work can be put through on a steady production basis. The total overhead can be charged to the repair work, which is proper, as without the rebuilding work the overhead would not only be as much but actually more by the amount of idle time between jobs. Of course where the rebuilding is the main issue and repairs are incidental the above would not apply and the overhead would have to be applied to rebuilt machine costs in some proportionate manner.

Another important feature of the motor-repair shop is the maintenance of proper stocks of material and finished merchandise.

The contractor-dealer can depend considerably on his jobber for his material, but with the exception of some of the larger cities we find very few jobbers that carry any stock of material such as required by the repair shop. This means that the repair man must maintain his own stocks and as the service he renders depends vitally on this stock it is very important that it is kept up. One of the best methods of doing this is by the use of a perpetual card inventory. This sug-

gestion is sure to meet with opposition, and rightly so, if the system put in is top-heavy and not adapted to the business.

Now here is the secret of the success of a stock-card system for a small repair shop, especially where practically every job must be priced on account of time and material billing: First, put all material in a locked stock room with one boy or man in charge and responsible. Material should be issued only on requisition, using a small slip with a place to check deduction from stock and charging to job. The stock card should also be a price card so that in one operation the stock man deducts the quantity from stock and gets the cost price on the requisition slip. The slip next goes to the office to be filed in the job envelope or posted to the job ticket. The usual objection to the stock card is on the grounds of extra work and extra help, but if the old system is analyzed it will be seen that the same or more work is being performed and with less efficiency. In our old system the shopmen laboriously recorded material that is now quickly and accurately done by the stockman. In the old way a clerk priced a mixed list in a slow and inefficient manner. Now the stockman gets the price instantly from a ready card and at the same time with little extra effort strikes a new balance. Instead of a large number of stock clerks so to speak, each working a few minutes a day, we have only one who works efficiently. Where the stockman would not be kept busy all day with stock, he can fill in by cutting insulation, making brushes or doing other odd jobs. In a real small shop of two or three men one can devote part of his time to stock records. With the new visible-type card racks, the work can be done quickly.

One other bugbear of the perpetual card system is the matter of small items of material with low value, such as soldering paste, solder, paint, glue, etc., doled out in almost immeasurable quantities. These can be handled very easily on a budget basis. They are issued to the shop in standard quantities and so taken care of on the cards, being charged to "Budget Material." The foreman then makes an estimate of budget material used on each job and charges it to the job in a lump sum —thus eliminating many entries that otherwise would be needed.

Such a card system is invaluable to the repair shop as it prevents running out of important items, keeps stock investment to a minimum, boosts turnover, makes it possible to buy more intelligently and forms an up-to-the-minute cost record of material used.

Service is a word that has been very much abused in business, but if there ever was a business where service was spelled in capitals and meant everything that has ever been connected with the word that business is the motor-repair business. When an important motor breaks down, its owner wants it back in operation with the least possible delay. "Alibis" about lack of men or material do not interest him. If the machine is important enough, he is willing to spend money for overtime work or for making up special parts that could be bought much cheaper from distant factories; in fact, everything that will save time is acceptable without a great deal of regard to cost. The shop that maintains the men and equipment and material stocks to take care of this class of customer promptly and efficiently does not have to worry about price-cutting competition. A great reputation for real service is one of the best assets a repair shop can have.

Such a shop may lose a customer through intensive solicitation or price-cutting on the part of its competitor, but the customer will soon be back if he does not get real service.

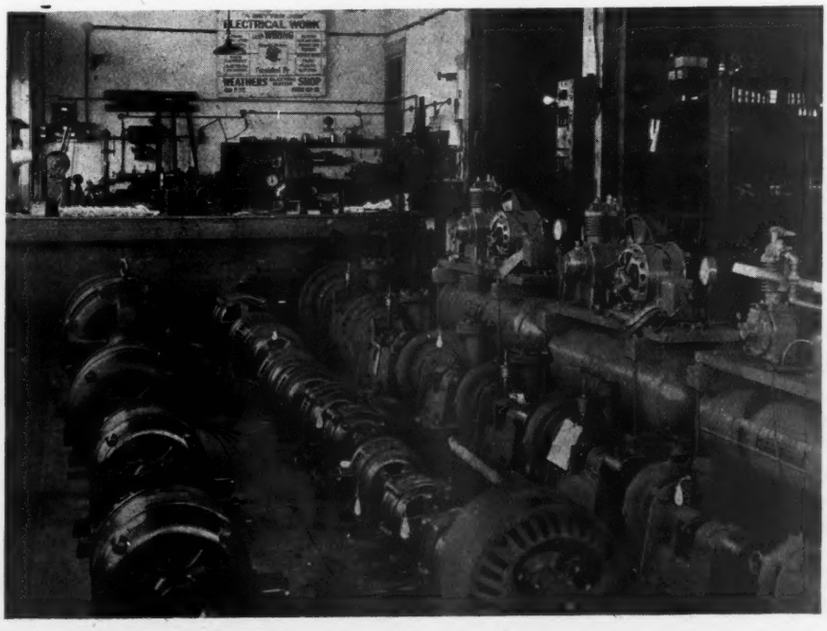
This service must not only be top notch as to speed but also as to quality of material and workmanship. The material should be only the best of its respective kind. It is poor economy to try and save a few pennies per yard or pound of material when such saving may cause a breakdown on a job where the labor and overhead involved is many times the total cost of material used. Likewise with labor, the high-grade workman is the best investment in the long run. Cheap, inefficient workmen will waste material and make dissatisfied customers through defective workmanship.

Since repair work is an expensive proposition at its best in comparison with the original cost of apparatus, everything possible should be done to reduce costs. The liberal use of labor-saving machinery is one of the best means to offset the high labor charge and at the same time make better service possible. Wherever possible the original factory methods should be duplicated. A trip each year to East Pittsburgh, Milwaukee, Schenectady or other motor-manufacturing centers is very important and will help you do better work.

To sum it all up, good service in a motor-repair shop requires an efficient combination of high-grade men, materials, equipment and record forms.

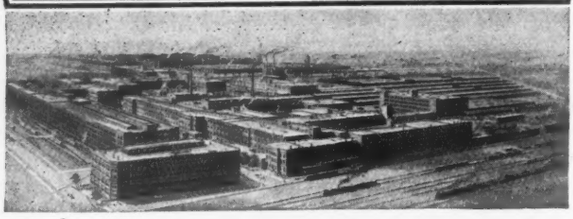
If there ever was a business where service was spelled in capitals, it is the motor-repair business.

The shop that maintains the men, equipment, and material stocks to take care of this work promptly and efficiently does not have to worry about price-cutting competition. This service consists not only in repairing motors quickly, but in making loans or renting spare equipment, as well as being able to supply new or second-hand equipment.



INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, January, 1925

You Can Do Whatever You Think You Can

THE first of every new year presents an opportunity for cleaning the slate of old-year deficiencies and failures and the making of new resolutions. It is good that this is so, for by our experiences, good or bad, do we profit when serious consideration is given to those things that tend toward personal advancement or larger business accomplishments.

Whatever may have been your lot in 1924, for the new year make your plans comprehensive in scope and definite in detail—aim your hopes high, and load yourself to the capacity of your ability. Remember that plans narrow in scope and small in possibilities stir up little enthusiasm, while an aspiration for big things that you believe possible, places you in the group of forward thinkers and doers. The world expects more of you year by year and you are better fitted after each twelve-month period to do the things you might not have aspired to during the years that have passed.

Edgar A. Guest furnishes a lot of inspiration in the following lines:

Success! It's found in the soul of you
And not in the realm of luck.
The world will furnish the work to do
And you must furnish the pluck.
You can do whatever you think you can;
It's all in the way you view it,
It's all in the start you make, young man,
You must feel that you're going to do it.

Let Mistakes Teach Their Own Lesson

RECENTLY the coil winder in a repair shop made an error which necessitated junking a large number of armature coils. He frankly admitted that it was a careless mistake and expressed his regret over its occurrence. Nevertheless, the foreman promptly discharged him, although his previous record was good and he was known as a careful, conscientious workman. When he applied for a position at another shop he told the whole story of his dismissal, and was hired at once.

Whether the first foreman acted too hastily or was justified in the course he took, may be open to argument. However, the man who hired this winder, knowing all of the facts in the case, explained why he did so as follows: "This man has had considerable experience and is a good winder, but he is a better man now than he was before because he has *learned his lesson.* Unless I am badly mistaken he is going to be much more careful from now on; he is going to be sure that he is right—and that is the kind of a man I like to have."

Leaving out of consideration the habitually careless workman, who is expensive at any price, the question of what to do with the man who makes one or two bad mistakes is not easy to answer. The natural impulse is to discharge him, which is, of course, an easy matter; to get a better man in his place may not be so easy. Moreover, there is no assurance that the new man will not make mistakes which are just as bad or worse, unless he has sometime been discharged or otherwise disciplined for an error in judgment, or carelessness, and thereby learned *his* lesson.

Although circumstances may clearly indicate the best course to pursue in a given case, it is probably safe to assume that when a conscientious workman makes a costly but unavoidable mistake he is just as sorry about it as anyone else is, and resolves that if carefulness will prevent it he is not going to make that mistake again. Such a frame of mind is worth a whole lot of discipline and is one of the best possible forms of insurance against careless slips of mind or hand.

Where Will Your Future Executives Come From?

ONE of the most common causes of disagreements is ignorance of, or failure to appreciate, the other fellow's viewpoint. If we do not understand what he is trying to do, or what his motives are, it is easy to infer that he is indifferent, unfair or that he uses poor judgment. In this connection the following letter received by the Editors of INDUSTRIAL ENGINEER is of unusual interest:

I was pleased with Mr. Chester A. Williams's very fine article on page 551 of the November issue, but feel obliged to take exception to his final paragraph, in which he seems to say that good men are hard to find.

There are hundreds of splendid chaps everywhere, possessing engineering or technical training—many of them, like myself, with considerable all 'round practical experience—who are ambitious and very anxious to completely finish their trade practically and theoretically, even at some expense to themselves. These men are willing to go anywhere for the chance of getting a decent show at a substantial future. They are willing to give maximum hours and their best efforts at any wage during such necessary apprenticeship, but are often unable to secure openings in worth-while plants that will give them this opportunity of definitely finishing their trade and quickly becoming in some form, a tangible, profitable asset to industry.

We are not afraid of work, much less of dirtying our hands, but the fellow determined on getting his electrical trade first, before expecting the big money, is facing a long, hard, discouraging proposition due to the almost complete absence of any degree of co-operation in his welfare among the various industrial plants and contractors, especially in the East.

American industry has a plentiful supply of real good, live material in its new recruits; men who are capable of development into any future responsibility—but they must receive some encouragement which, I am sure, would result in greatly minimizing any plant's labor turnover.

In these statements there is much food for thought on the part of plant owners and executives. Granting that the interests of employers and workmen do not always exactly coincide, each wants something that only the other can give. The employer wants skilled service, a sense of craftsmanship and the kind of loyalty and faithfulness that can be depended upon to do the best possible job under any circumstances. The workman wants pay commensurate with his skill and the value of his services, a reasonably permanent job and a fair chance to win advancement in responsibility and rewards.

If a workman feels, rightly or wrongly, that he is not getting these things, he will inevitably seek a new position. If an industrial plant gets the name of being unfair in one way or another to its employees, it will have difficulty in securing and holding the ambitious young fellows who will be in responsible positions ten or twenty years from now.

Perhaps the statements in the above letter do not apply to you, but it will do no harm to check up your practices and policies in the light of this letter and see if your future master mechanic, chief electrician or other executive now in the ranks but as yet unknown is being properly trained and encouraged to work for the position which you may some day be glad to offer him.

The Peg on Which Good Salaries Hang

IN THE Buick body factory at Flint, Michigan, one of the largest of its kind, the man responsible for getting production through the curtain, light and repair department is Foreman Clyde Wing. This statement may not mean much until you know that Mr. Wing is just twenty-one years old and one of the best-liked leaders in the Buick works. He started in factory work five years ago as an office boy and simply worked himself out of that job by not only being the busiest office boy around the plant but the most observing one. It was not long before he was transferred to a division of the production department, where his remarkable ability to grasp details and effectively follow up the necessary routine on production procedure brought him a position, in the short period of five years, that has taken many others a life-time to acquire.

We cite the case of Clyde Wing to illustrate the fact that in factory work today the call is for men who possess initiative, who are self-starters, in brief, and do not require supervision any more than the president of the corporation requires supervision. When men ambitious for more salary and promotion from routine work can show that they have the qualifications to see beyond the horizon of the average fellow worker and at the same time demonstrate this by actual results on any job to which they may be assigned, then the promotion of these men will be just as quick and certain as that of Clyde Wing.

Imagination of inherent ability is never a substitute for accomplishment. All the Clyde Wings have stood the test and won on their merits, not on their conversation about themselves. In these days of high-speed, specialized production, it's not what you think but what you know about a thing that interests the boss—and that's the peg on which good salaries hang.

Don't Risk Your Reputation for a Few Cents

IN HIS article on operating motor repair shops, which begins on page 27 of this issue, Mr. Svendson makes the following pertinent statements: "The material should be only the best of its respective kind. It is poor economy to try and save a few pennies per yard or pound of material when such saving may cause a breakdown on a job where the labor and overhead involved is many times the total cost of material used. Likewise with labor, the high-grade workman is the best investment in the long run."

Economy in buying labor and material and in managing a repair shop is a laudable virtue and worthy to be practiced so long as it results in an actual, not apparent, saving in money, time and effort. Nevertheless, there is a point beyond which economy is not profitable. That is the point where quantity or quality of materials, labor and workmanship are cut below the minimum requirements for a good, serviceable job. That is the kind of economy that wastes a dollar in trying to save a few cents. A saving of a dollar or two on a gallon of varnish will make only a trifling difference in the cost per coil, while the difference in the quality of the varnish may make all of the difference between a job that stands up in service and one that does not.

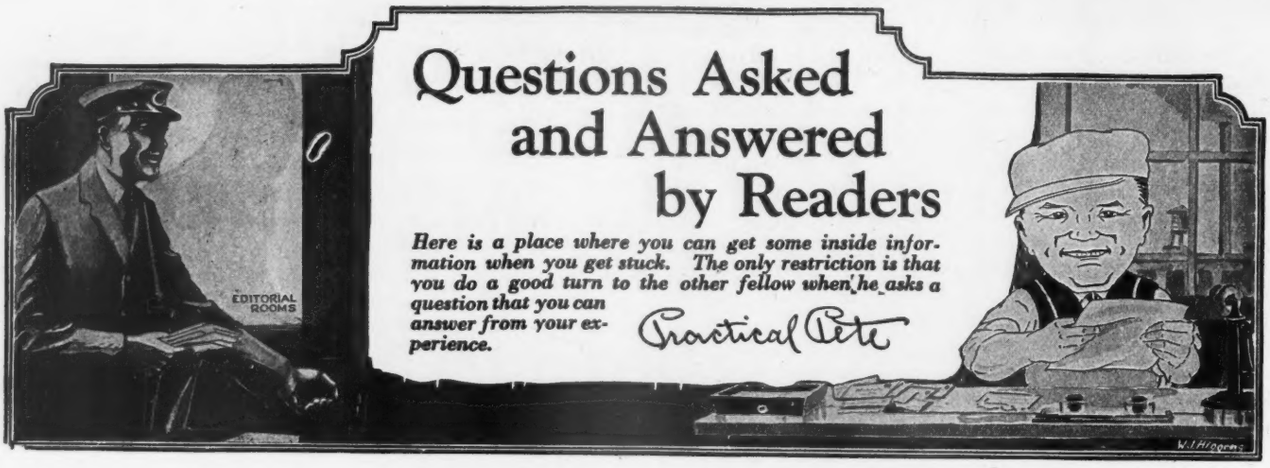
The same thing is true of insulating materials, labor and all of the elements that enter into any repair job. Cheap materials and cheap labor may be worth all you pay for them—but if you do not pay much for them, as compared with the corresponding prices for standard materials and high-grade workmen, you can not expect much out of them.

If your personal reputation, or the reputation of your department, is worth anything to you, do not risk it for a few cents.

Following Precedent or Following the Leader

PERHAPS in no other industrial field has precedent been followed so blindly as in material handling. Man-power in the form of "common labor" has been relied upon to perform this service. Ordinarily it has been considered as "cheap" because it has been placed as a lump in the general heading "overhead." However, those concerns which have made a detailed cost analysis of this work have found that this labor is expensive.

In addition to this, immigration restrictions have reduced the number of men available for this work as those who come into this country can soon get better jobs. To some this may seem a calamity while to others it is merely a demand upon their genius for a method of doing this work mechanically. While many devices have already been invented and placed on the market to do the work of strong-arm labor, industry as a whole has been reluctant to forsake precedent and take advantage of them. Those companies which have applied this equipment have found that it not only results in the elimination of the troublesome problem of providing this labor but at a considerable reduction in cost. This is the time to disregard precedent more than ever and adopt material handling methods shown to be practical by those who are leaders.


EDITORIAL ROOMS
Questions Asked and Answered by Readers
Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.
Practical Pete
W. J. Higgins

Who Can Answer These?

Locating Trouble in Power Circuits Run in Conduit—Can some reader tell me what is the usual method of testing for and locating short-circuits, grounds and so on in power circuits which are run in conduit, and from which branch circuits for motors and other equipment are taken off at intervals? I shall be very grateful for your suggestions and advice.
Pittsburgh, Pa. J. L. B.

* * * *

Throwing Large Squirrel-Cage Motors Across the Line—Will someone who has had experience with starting large squirrel-cage motors (50 hp. and larger) by throwing them directly across the line, please report their results? Has such practice injured the motors in any way? Has it resulted in any damage to the machinery driven? Has it interfered with the supply of current to other motors in the same plant?
Indianapolis, Ind. D. W. T.

* * * *

Testing D.C. Armatures With Voltmeter—(1) Will some reader please tell me where to place the lampbank leads on the commutator when testing direct-current armatures with a voltmeter? For example, in the case of a four-pole armature should I touch the leads to the commutator on the quarter or on the half? Where should the leads be placed on a six-pole armature; or an eight-pole armature? (2) When testing a four-pole armature I touched the lampbank leads to the commutator on the quarter and got a good reading on the meter until I came to the next quarter of the commutator. Then the deflection was in the opposite direction. When I reversed the meter leads there was no reading on two bars of the quarter. Continuing ahead I got a good reading until the next quarter was reached. What did that indicate?
New York, N. Y. H. B.

* * * *

Making Tight Joint Around Prism Lights in Cement Sidewalk—Will some reader of INDUSTRIAL ENGINEER please tell me how to make a durable, water-tight joint between the cement slab holding the square prism lights and the cement sidewalk, over our basement? The crack all around these slabs is from ¼ in. to ⅝ in. wide and 1½ in. deep to the flange that carries the weight of the slab. The temperature varies from about 15 deg. F. in winter to 125 deg. F. or more in summer.
Dallas, Tex. F. A.

* * * *

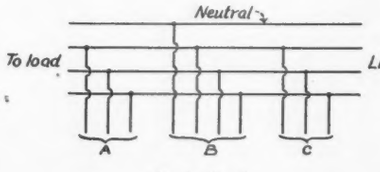
How to Determine Amount of Plugging Resistance to Use—I would like to know the right way to figure the amount of resistance used for starting series motors that are plugged, such as on blooming-mill, roll-table motors, crane-trolley motors, or any motor that is subjected to plugging service. I would also like to know how to figure the resistance used in the secondary circuit of slip-ring motors driving fans.
Mingo Junction, Ohio. E. E. S.

Connecting Watt-hour Meter to Three-Wire Circuit—Will some reader please give me a diagram and explanation of how to connect a watt-hour meter to an Edison three-wire circuit? Is a special type of meter required? Why?
Bellaire, Ohio. J. R. B.

* * * *

Connecting Westinghouse Type C Watt-hour Meter to 3-Phase, 4-Wire Circuit—Will some reader please tell me how to connect a Westinghouse, type C, switchboard, induction watt-hour meter to a three-phase, four-wire system having 2,300 volts between the neutral and each phase wire and 4,000 volts between phases? In the diagram, *A* and *C* are three-wire circuits supplying current at 4,000 volts, three phase, while *B* is a three-phase, four-wire circuit. One meter must measure the total power consumed.

The current transformers must be delta connected and three 2,300-volt voltage transformers must be used, as there are no 4,000-volt transformers on hand. I should also like to know whether it makes any difference if two or three current transformers are used on feeders *A* and *C*.
Guayama, Porto Rico. R. S.



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Standardizing Weight of Belting—I understand that some plants have standardized the weight of belting which they use; that is all belts are single-, double-, or triple-ply, the width of the individual belts being properly proportioned to the power that is to be transmitted. I should judge that this plan would simplify stock-keeping and reduce the amount of belting necessary to be carried on hand. However, I should like to know if any of the readers of INDUSTRIAL ENGINEER have done anything of this sort and what the advantages of such a procedure are.
Chicago, Ill. H. D. B.

* * * *

Winding Data for Peerless Fan Motor—I have a single-phase, 60-cycle, 110-volt fan motor, manufactured by the Peerless Electric Co., Warren, Ohio. It has twenty-four slots, solid rotor, no starting switch and appears to have a three-phase winding. I shall appreciate it if some reader can give me a diagram of the connections, as well as information on the choke coil in the base of the fan. The motor has evidently been rewound; sixteen coils have sixty turns of No. 25 s.c.e. wire. The coil pitch is 1-and-6. The choke coil has also been rebuilt, but the motor does not run fast enough to disturb the air and also has a ground in it. I believe the motor was not rewound correctly as to size of wire and number of turns.
Mishawaka, Ind. L. C.

Answers Received To Questions Asked

Lining Up Sprockets for Chain Drives—Can some reader tell me the best and simplest method of lining up sprockets, or shafts, for chain drives? We frequently change machines around and install new drives or replace old ones, and I should like to be sure that we are lining these up properly.
Decatur, Ill. J. L. B.

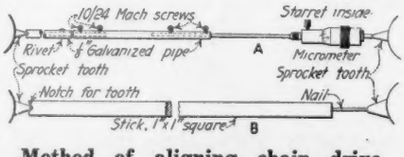
With reference to J. L. B.'s question in the November issue, I presume that he has reference to chain belts of the type manufactured by the Link-Belt Company, the Morse Chain Co. and the American High Speed Chain Co. I have handled such drives for the past six years and use the following methods, which have always proven entirely satisfactory:

Referring to the sketch, take two pieces of ⅛-in. galvanized pipe of the proper length to suit the requirements, which depend entirely upon the centers of the shafts. About 42 in. to 48 in. is the maximum that I have had to deal with, with a 2½-to-1 or 3-to-1 ratio. Drill two holes through the end of one pipe, the first hole being about ¼ in. from the end; the other hole should be about 1 in. further back. I use a No. 21 drill. Tap out the holes for 10/24 or 10/32 machine screws. Drill both ends of the first piece of pipe in this manner:

The second piece of pipe requires no holes, but a round piece of iron stock should be driven tightly in one end for fitting into the second section. Drill a small hole through the pipe and rod and put in a small iron rivet, peening it over on the under side.

Round out the opposite end of this piece sufficiently to fit over the sprocket tooth. Then fit a Starrett inside micrometer into the other end of the first piece of pipe. At (A) in the sketch is shown a complete assembly of the gage ready for use. This is really an adjustable pin gage.

Place the two sprockets face to face



Method of aligning chain drive sprockets, A, by means of improvised pin gage and, B, by a wooden stick.

in approximately the position in which they are to run; then center them by squaring the sides with a steel straightedge or its equivalent. Gage in between the teeth, as shown in the sketch, until the outside edges of the two teeth selected are within 0.003 in. of being parallel. If the centers are then correct, the sprockets are lined up about as closely as it is possible to get them for all practical purposes. Sprockets should be carefully examined before placing on the shaft to detect blowholes and eliminate any high spots that might exist. When machining, blowholes in the inside of the shaft hole cause the tool to jump and the result is high spots. If this condition is not remedied a "wobble" will result.

In case an inside micrometer cannot be obtained, a piece of yellow pine 1 in. square can be used. Cut the timber to the proper length, notch it on one end and drive a small nail into the other, filing off the head to a round point. Adjustment can be made by driving in or withdrawing the nail with a pair of pliers. If this outfit is carefully used the results obtained will be about as good as with the micrometer.

A chain belt should never be too loose; the sag in operation should never be over 1 in. or 1½ in. on the slack side; otherwise in case of a reversible drive or dynamic braking a slap will result.

For roller sprockets a good straightedge or fine chalk line applied to the sides of the sprockets to bring them center to center and in alignment, should be sufficient. I have used the above tools for a good many years and have yet to hear a complaint about a drive so lined up. The tools employed can be obtained in any good industrial plant machine shop. Any mechanic can make for himself the two pieces of pipe used for an extension, and when once made they are always ready for use. The joint in the pipes is for dismantling so that they can be placed in the tool case; otherwise a joint is not necessary unless the shaft centers are rather short.

General Engineer, P. S. PENDER.
Metropolitan Engineering Co.,
Granite City, Ill.

* * * *

How Does Change in Speed of Motor Affect Horsepower?—I shall appreciate it if some reader of INDUSTRIAL ENGINEER can answer the following question: We have a 3-hp., 3,600-r.p.m. motor which we are changing to operate at 1,800 r.p.m. I should like to know what the approximate horsepower of the motor will be after this change, if we use the same number of turns of the same size wire in the stator.

Enid, Okla. C. E. S.

In answer to the question by C. E. S., in a recent issue, the horsepower will be approximately half of what it was originally. Likewise, the applied voltage must be reduced to approximately half of its original value, because a change in speed, which varies inversely as the number of poles must be accompanied by a change in voltage. It must be remembered, also, that a change in the pitch factor must be accompanied by a change in the applied voltage if the operating characteristics of the motor are to remain normal. The new pitch factor should not be smaller than 0.5 nor greater than 1.5. There are practical limits beyond which this form of reconnection cannot properly be carried. The connection which you suggest would not normally operate at the same voltage nor would the horsepower developed be the same. If the speed of a motor is reduced one-half by a change in the number of poles, in order to operate it at the proper voltage, special taps from the transformer would be required. Otherwise, some other changes would have to be made in the motor winding at the same time that the number of poles were changed. If C. E. S. will tell me how many coils are in this motor and the original connection, I will be glad to tell him how to group the coils for the new speed.

Ass't Superintendent, H. J. ACHEE.
City Water and Light Dep't.,
Woodward, Okla.

* * * *

Operating 25-Cycle Transformers on a 60-Cycle Circuit—We are operating a 2,300-volt, sixty-cycle, three-phase system and in a short time will be called upon to furnish some additional lighting and power service. Our present transformers are not sufficiently large to handle this additional load and we do not wish to purchase new ones as the load will be on for only a few days. We can rent 2,300-volt, twenty-five-cycle transformers and I should like to know if these will work satisfactorily on the sixty-cycle current. Will the secondary voltage be the same as on twenty-five cycles? If not how much will it be below normal?

Carthage, Mo. A. P. K.

In the November issue, A. P. K. asks if 25-cycle, 2,300-volt transformers can be expected to operate satisfactorily on a 60-cycle circuit. The main difference between 25-cycle and 60-cycle transformers is in the iron laminations. Because the reversals are slower with 25-cycle current than with 60-cycle, the iron has more chance to get saturated. Therefore, 25-cycle transformers are designed with thicker iron laminations and more iron, in order to take care of the increased heating. Using 25-cycle transformers on 60 cycles only means that the iron will heat much less because the higher current frequency does not have time to build up the magnetism. The core loss will, therefore, be less than if the transformers were operated on their normal frequency. The copper loss should remain the same. The regulation at unity power factor should be the same. The secondary voltage should be the same as though the transformers were operated on their normal frequency.

Using these 25-cycle transformers, as suggested, should be satisfactory as an emergency measure, but it would not pay to buy 25-cycle transformers when 60-cycle units can be obtained, because of the much higher price of the 25-cycle equipment.

R. F. EMERSON.
Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

* * * *

Referring to A. P. K's. question in the November issue, a standard transformer designed for a definite frequency may be operated at frequencies which are considerably higher or lower than normal. If the transformer is designed so that at normal frequency and full load the copper and iron losses are equal and the efficiency maximum, at lower frequencies the iron loss will be larger than the copper loss and at higher frequencies the copper loss will be the greater.

A transformer designed for a given output and frequency can be operated at the same output on a higher frequency with somewhat reduced heating, but if operated on a lower frequency it will run somewhat hotter and the efficiency will be slightly lower. Modern transformers, however, usually have sufficient capacity to be operated on half-frequency without injury. When operating a 25-cycle transformer on a 60-cycle circuit, a power transformer would give better results than a lighting transformer, because the core loss and the copper loss are about equal in the former, whereas in the lighting transformer the copper loss will be greater than the core loss. The secondary voltage will be the same as when the transformer is operated on 25 cycles.

Thompsontown, Pa. C. D. SHAFFER.

* * * *

Replying to the question by A. P. K. in the November issue, transformers designed for operation on a 25-cycle circuit will operate satisfactorily on a 60-cycle circuit; they will, in fact, operate better at 60 cycles than at 25 cycles. This is due to the fact that for the same kva. capacity a 25-cycle transformer must have a core of greater cross section. The reason may be understood by referring to the standard formula, $E=4.44\times f\times \phi\times T\times 10^{-8}$, where (E) is the voltage, (f) the frequency, (ϕ) the total flux, and (T) the number of turns.

This formula may be written, $E=K\times f\times \phi\times T$, where $(K)=4.44\times 10^{-8}$.

For a certain voltage the product of (f) and (ϕ) must be constant, since the number of turns is fixed; therefore, if (f) is changed from 25 to 60 cycles (ϕ) must become less or decrease in proportion to the increase in frequency. This decrease in the flux will more than offset the increased losses, due to increase of frequency, in hysteresis and eddy currents.

The secondary voltage will be the same as at 25 cycles.

As a general statement it should, however, be borne in mind that a transformer designed especially for operation on a 60-cycle circuit would overheat and probably burn out if operated on a 25-cycle circuit.

C. OTTO VAN DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

* * * *

Replying to the question by A. P. K. in the November issue, the following statements may be made: (1) The iron losses will decrease. (2) The reactance of the transformers will increase in the ratio 60/25. (3) The impedance will be increased. (4) If the load is carried at 100 per cent power factor the secondary voltage will be the same, or normal, regardless of whether the current supply is 60 cycles or 25 cycle. However, this is rarely the case and as the power factor drops the voltage drop will be much above normal; that is to say, it will be greater than it would be under the same conditions of load and power factor at 25 cycles. The voltage drop will depend on the design of the transformer and in the absence of the design data it is not possible to say what the resultant secondary voltage will be. (5) If the 25-cycle transformers must be operated in parallel with 60-cycle transformers their capacity will be decreased because the impedance is increased. When several transformers working in parallel all have the same impedance the load will be distributed among the different trans-

formers in proportion to their capacities. However, if the impedances are not the same the transformer having the higher impedance will take the smaller load.

Liege, Belgium. P. VAN HERK.

* * * *

With reference to A. P. K.'s question in the November issue, it will be satisfactory to operate 25-cycle transformers on a 60-cycle circuit. The secondary voltage will be the same as on 25 cycles.

The iron loss will be about one-half of the value it would have on 25 cycles, while the copper loss will be approximately the same. This means that the transformers will have a greater capacity on 60 cycles than on 25 cycles, the amount depending upon the ratio of iron loss to copper loss in these particular transformers. However, increased loading is probably not important in this case.

East Cleveland, Ohio. L. T. JOHNSON.

* * * *

Replying to the question by A. P. K. in the November issue, 25-cycle transformers can be used on a 60-cycle circuit under certain conditions. For example, they will carry about one-half their rated load very well, but they will run warmer than normal and both iron and copper losses will be greater than would be the case if the transformers were designed for 60-cycle operation. The increased iron losses would be caused by an increase in eddy currents as the laminations of 25-cycle transformers are usually thicker than those in 60-cycle transformers. Eddy currents are proportional to the thickness of the lamination and to the frequency.

The copper losses will be greater for a given current than in 60-cycle transformers as there is more wire in 25-cycle transformers, and the latter will thus operate at a lower efficiency at 60 cycles. The secondary voltage will, under light load conditions, be normal, while the regulation will be less close, depending on the load.

Muncie, Ind. GEORGE CROPPER.

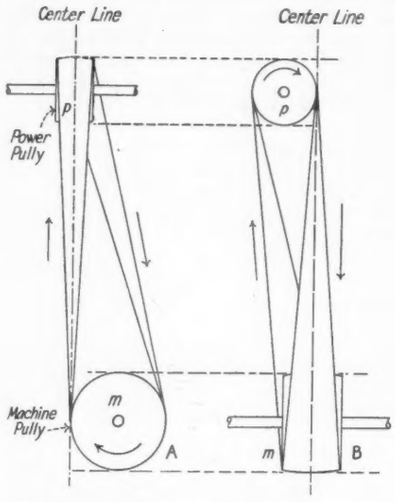
* * * *

How Should This Machine Be Placed?—It is common practice to place a pulley at right angles to a lineshaft which, of course, means that the belt has no twist in it. However, we have a 125-ton press and would like to place it in such a position that the pulley on this press will be 45 deg. from the lineshaft. I should like to know, (1) if this is an unusual way of running a belt, and (2) how should the machine be placed with the pulley in this position, so that the belt will not be continually slipping off.

Philadelphia, Pa. A. T. S.

In answer to A. T. S.'s question in a recent issue, almost any machine can be placed at an angle of 90 deg. or less away from the power lineshaft, providing that the belt is properly lined up to both pulleys. In the first place, note the direction of the power pulley (P), in the illustration (A), then drop a plumb line off its periphery **toward** which the belt is traveling.

The machine pulley (M) must then, if turned at 90 deg., have its periphery just touch the plumb line. It will be noted that as the belt is traveling from the machine pulley (M) up toward the power pulley (P) it approaches the latter along a perfect center line, which is correct.



Method of lining up lineshaft and machine pulleys when shafts are at right angles.

Now, the slack side of the belt, going downward from the power pulley and approaching the machine pulley, must travel along a line at right angles to the shaft of the machine pulley, see illustration (B), so as to ride upon the latter on the face center.

This adjustment may be rather difficult if the machine cannot be shifted into line, but easy if it can be. However, a plumb line or straight edge extended upward from the face center of the machine pulley, should just touch the periphery of the power pulley, as in (B).

If the direction of the lineshaft is reversed from this diagram, the pulleys must be lined up in other positions, as that side of the belt **approaching** each pulley **must** be on its **center line**, and not approach it from an angle. However, the belt can leave each pulley at an angle, with no bad effects.

If pulleys and belt are properly lined up to a machine at any angle up to 90 deg. from the power shaft, no guides will be required to keep the belt on the center of the crowns, for it will ride there perfectly. If it does not, the lining up was faulty.

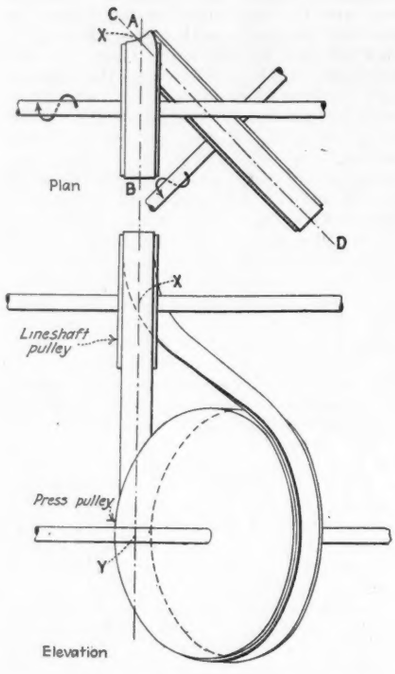
Any ratio of pulley diameters may be used.

New Britain, Conn. H. S. RICH.

* * * *

Referring to the question by A. T. S., in a late issue, the condition which he describes is simply one variety of the quarter-turn belt drive, and while such a drive is not common, it could hardly be called unusual. The chief reason it is not more common is that the driven pulley, if its shaft is to be level, must be located below the lineshaft pulley as shown in the accompanying diagram.

If the press is run the other way, it must be shifted to the opposite side of the lineshaft. The only precaution essential to observe in a drive of this sort, is that the point at which the belt leaves one pulley of the drive must be in the plane of the other pulley of the drive. Thus calling the plane of the lineshaft pulley (AB), in the diagram, and the plane of the press pulley (CD), it will be seen that the point (X) where the belt leaves the lineshaft pulley is in the plane (CD) of the press pulley and that the point (Y) where the belt leaves the press pulley is the plane (AB), and that these points are directly over one another.



When the lineshaft and driven shaft are at an angle to each other, the point at which the belt leaves one pulley of the drive must be in the plane of the other pulley.

Drives of this sort work better where belt centers are long compared with the diameters of the pulleys and with the pulleys well crowned, but that there is more or less latitude in setting can be seen from a case in one shop where I worked that had a row of drill presses located directly under the lineshaft and driven by quarter-turn, shifting belts.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.,
New Haven, Conn.

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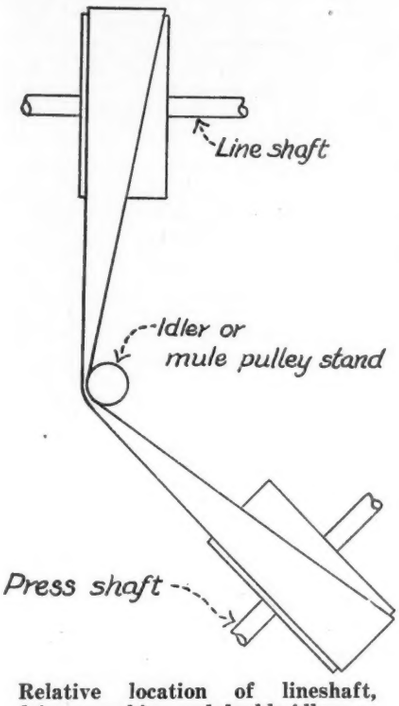
In reply to A. T. S., whose question appeared in a recent issue, on special drives or when turning corners it is not an uncommon thing to use a belt drive similar to the one which he described. This arrangement is more common with rope drives, however, and in that case is much easier to handle, because the rope does not resist twisting as much as belting does. This type of drive is used only in special cases and is more troublesome than the ordinary type; also it tends to shorten the life of the belt. I believe that A. T. S. will understand the principle from the diagram. The exact location of the idler or mule stand can be determined by experiment. If he is interested in the subject to any extent, I would refer him to Marks Mechanical Engineers' Handbook which gives good "dope" on this subject. It is, as well, a good ref-



Relative location of lineshaft, driven machine and double idlers or mule stand for angular drive.

erence book on all kinds of mechanical problems.

Birmingham, Ala. GRADY H. EMERSON.

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Why Do These Commutators Turn Black? —I am experiencing a great deal of trouble from blackening of the commutators on two G. E. belt-driven, type ML, compound-wound, 125-volt, 950-r.p.m., 13 kw., d.c. generators which are used as exciters. After smoothing with sand paper, it is only a matter of a few hours until the commutators are in the same condition again. I have tried turning the commutators in a lathe and undercutting the mica, polishing, sanding, using Ideal commutator stone and tightening the commutator. Also, I have used four different grades of brushes and am now using Speer E-25 brushes. There is no sparking at all under varying loads. The setting of the brush holders was changed from leading to trailing and I found that they worked best leading. I have tried the brushes at different angles and found that the best results were obtained when they were set at about 80 deg.

We wipe off the commutators once each day with a dry piece of canvas. I have checked the brushes for the neutral position. The tension on the brushes is 1½ lb. per sq. in. The temperature seems normal except when the commutators get very black as they will do if they go about a week without sanding. These exciters are only two years old and have been in actual service about one year each. I have had this trouble from the start.

I shall appreciate it very much if some reader of INDUSTRIAL ENGINEER can tell me what the trouble is and how I may cure it.

Woodward, Okla. H. J. A.

In answer to H. J. A., in a recent issue, it seems that you have tested for most of the usual sources of trouble without much success. Inasmuch as you are sure that the commutator is tight and remains tight when it warms up, I would advise you to see if the armature is lap or wave connected. If it is lap connected, I would consider putting in equalizers. For this purpose, divide the total number of commutator bars by the number of pairs of poles, plus one. Put in as many equalizers as there are pairs of poles and space them equally between the first equalizer, as any irregularity in the armature, field or air gap will cause sparking in a lap wound armature. I would also suggest that you make a bar to bar test with a millivoltmeter and lamp bank and see if all the bars read alike. There might be a partial open somewhere. A partial open on any bar will cause it to read higher than the rest. It would also cause sparking and blackening of the commutator in certain places.

Also check up the pole pieces to see if they are equally spaced. If they are not almost equally spaced commutation will, at times, take place when the coil is not in the neutral zone.

I think it would also be well worth while to go over the connections of the brush rigging to see if they are all clean and tight, so that more current will not be carried on one brush stud than on another.

Finally, make sure that there are no bulky splices or unnecessary bumps on the belt, as these will cause sparking.

I hope that these suggestions will be of some help to H. J. A.

NICHOLAS J. WEISS.

West New York, N. J.

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With reference to H. J. A.'s question in a late issue of INDUSTRIAL ENGINEER, the only possible cause that I can think of for this trouble is belt lacing or a similar source of vibration.

General Manager, W. C. KALB.
Corliss Carbon Company,
Bradford, Pa.

* * * *

In a recent issue H. J. A. mentions trouble from blackening of the commutators of two small generators.

There are several possible causes of this trouble. One of the most common causes is an overheated commutator, which may be due to overload or to sparking which, in turn, may be occasioned by incorrect brush tension or a variety of causes. Sometimes it will be found that too much lubricant has been used on the commutator.

An overheated commutator may not be very noticeable at first, but after running for some time the commutator may become heated sufficiently to decompose the carbon brushes, covering the commutator with a black film which increases the resistance between the commutator and the brushes and thus increases the heating. If the brushes get very hot a brush of higher conductivity should be used, allowing a higher current density per square inch.

I believe that H. J. A. has the brush tension set too low. This would cause sparking that might not at first be plainly visible to the eye, but enough to cause the brushes and commutator to become heated in time. The pressure should be from 1¾ to 2¼ lb. per sq. in.; a safe average would be 2 lb. per sq. in.

As several grades of brushes have been tried without improving conditions it may be that a larger brush is necessary; a machine of this size should carry 118 amp. at 110 volts and should have at least 4 sq. in. of brush surface.

Carbon-graphite brushes give very good results as the graphite increases the conductivity and reduces friction. Sometimes the operating qualities of brushes may be improved by saturating them with some lubricating compound, although this is something that must be very carefully done and then only when the conditions plainly indicate it.

New York, N. Y. DONALD L. HOARE.

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Answering H. J. A.'s inquiry in a recent issue, this blackening is generally caused by disintegration of the brush material, due to some abnormal condition, usually excessive current density. It is a simple matter to calculate the nominal current density in a brush, but the figure thus obtained may bear very little relation to the actual density. The distribution of load between spindles of a machine is not always uniform, nor is the distribution of load between the brushes on one spindle. Finally, the current density on one side of the brush may be very much higher than the current density on the other side. Thus the actual density may be many times the nominal, and the brush may be loaded up far beyond its capacity, until the bond near the contact surface is destroyed in consequence of the excessive temperature and disintegration commences. Sometimes glowing or cratering of the brush is observed under these conditions. Sparking is not necessarily much in evidence. The cure for this is to improve the running conditions as much as possible, and to mount a more refractory grade of brush, a slightly abrasive electrographitic quality usually being the most suitable.

Experience shows that when cratering occurs on a brush it is better to substitute a more refractory type of brush that will stand up to the conditions than to substitute a hard carbon with a high contact drop, in the hope of bringing the load within the capacity of the brush by reducing the circulating current in this way.

Projecting mica is a very fruitful cause of blackening. It lifts the brushes off the commutator, increasing the total I^2R loss and therefore the heating; it upsets the distribution of load, and thus causes excessive current density and local overheating. Finally, by acting as a milling cutter, it assists in the disintegration of the brush. Recessing the mica will often cure the blackening without any change of brushes, although it may be necessary to remove a considerable piece from the end of a brush if the material has already suffered from the ill treatment.

When burning of the commutator surface occurs (which is usually accompanied by visible sparking) this in itself tends to blacken the commutator. It also roughens the surface of the segments, which then abrade the brushes and thus accentuate the blackening. Again the cure generally is to use a slightly abrasive electro-graphitic brush, after improving the running conditions as much as possible and

especially putting the commutator into thoroughly good condition before mounting the new grade.

Blackening of the commutator surface not infrequently occurs on machines driven by gas engines, due to the corrosive action of the gases. If the commutator is thoroughly scoured, electro-graphitic brushes as described will usually prevent a recurrence of the trouble.

An excessive amount of dust in the atmosphere, such as coal, cement, or flour dust, is very likely to cause blackening by preventing intimate contact between brushes and segments, thus producing high local current densities and sometimes sparking which, of course, in itself tends to burn the brush and destroy its bond.

Oil vapor has sometimes been found to create a similar condition. Highly-lubricating, natural graphite brushes have proved very successful in cases where dust has been responsible, evidently by maintaining intimate contact and preventing the dust from working underneath the brush. For conditions where an oily vapor is present a slightly abrasive electro-graphitic brush has been found to effect a cure.

Morganite Brush Co., New York, N. Y. H. C. MILLS.

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H. J. A. asks a difficult question in a recent issue of INDUSTRIAL ENGINEER. The answer may be poor design. In my experience the only exception to this has been inequality of air gap.

In one particular case we had a motor that blackened under the negative brushes. The air gap was smaller on the bottom than on the top. We inserted shims under the top pole pieces, making the air gap equal all around the machine and the trouble disappeared.

If this remedy does not have any effect the only thing left is to slot the commutator (undercut the mica). This will improve matters somewhat, but if the commutator still continues to blacken the manufacturer should be notified and requested to make the machine operate as it should, without blackening.

Boston, Mass. EDWARD A. GIBBS.

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Advantages of Star- and Delta-Connected Motor Windings—I wish someone would kindly give me some information on the following questions. Why are some three-phase motors star-connected, and some delta-connected? What are the advantages of a star-connected motor over one that is delta-connected? I shall appreciate it very much if someone will explain this to me.

Toledo, Ohio. F. H.

In answer to F. H.'s question in the September issue, most manufacturers prefer a star to a delta connection for the reason that the delta connection requires 1.73 times as many turns for the same operating voltage, and these turns are of a smaller-size wire. There are several objections to the use of a large number of turns per coil. For example, more space is occupied in the slots for insulation, leaving less space for the copper. The coils are much less rigid, from a mechanical standpoint, and require more binding and bracing at the ends. Smaller-size magnet wire also costs more money per pound and the same number of pounds will be required in either connection. Further, it takes longer to make up a coil with a larger number of turns than to make one of larger wire and fewer turns. While it is not the best practice to use four-parallel star windings where two-parallel delta would serve the purpose, probably for the single-circuit winding the star connection is the better choice.

Donnacona, P. Q., Can. LEE F. DANN.

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In answer to F. H.'s question in the September issue, a large number of motors are built for stock and the windings used are such that by changing Y and delta connections and the series and parallel arrangements, it is possible to secure windings which will be suitable for a number of standard voltages.

The Y connection is more widely used in motors since the neutral point may be grounded. Also the slot factor is higher for a Y connection than for a delta connection. This means that for a Y connection only 58 per cent of the insulation required for a delta connection is used, or the ratio of copper to slot insulation is less.

CHAS. F. CAMERON.

Rock Springs, Wyo.

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In reply to F. H. in the September issue, I would say that so far as the operation of the motor is concerned one form of connection has no advantages over the other. Even in the original design of the motor it is often simply a matter of the designer's choice, although the star connection is probably the more generally used, whenever possible.

A given winding connected in star is good for 73 per cent higher voltage than the same winding connected in delta. In other words, a delta-connected motor must have 1.73 times as many turns per coil as a star-connected motor for the same voltage. This is because the star connection gives 1.73 times as many "effective" turns in series across each phase. This is roughly evident from studying the ordinary symbols for star and delta connections.

The usefulness of the two forms of connection lies with the designer. They give him more combinations which he may "juggle" to meet various conditions. For instance, in a large, low-voltage motor it might work out in the design that for a star connection there would be 2.31 turns per coil. It is impossible to make a coil with a fractional number of turns, but for a delta-connected winding for the same motor the number of turns would be $2.31 \times 1.73 = 3.996$, or very nearly four turns per coil; so the designer would use four turns per coil and a delta connection. This is, of course, merely an example, but it gives the idea.

A full discussion of this subject could not be given here and I would refer F. H. to A. M. Dudley's book, "Connecting Induction Motors," particularly the chapter on reconnecting old motors for new conditions. This book can be obtained from the McGraw-Hill Book Co., and is worth many times its cost.

Walkerville, Ont., Can. R. B. TURNER.

Priming Coat for Plaster and Brickwork—Will some reader of INDUSTRIAL ENGINEER please tell me what kind of sizing or priming coat should be applied when brickwork and plaster walls are being painted for the first time? We wish to paint the walls and ceilings of both office and shop and I understand that some preliminary treatment is necessary before the finishing coats of paint are applied.

Cleveland, Ohio. L. McC.

Replying to L. McC. in the October issue, when painting brick and plaster walls for the first time it is customary to apply a priming coat, which may consist simply of glue and water, in about the proportion of ½ lb. of glue to 10 qts. of water. The glue should be dissolved in the water while hot, and allowed to cool before using.

A better and more easily applied priming coat consists of, 1 gal. linseed oil, 2 qt. cheap varnish, 1 qt. turpentine, ¼ pt. drier.

To this is added sufficient white lead to give it a little color, so that in applying one can easily tell how much surface has been covered.

If the final finish is to be gloss, at least two coats of flat will be necessary before applying the gloss.

Guilford, Me. DONALD MAXFIELD.

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In reply to the query of L. McC. in the October issue, I would suggest the following treatment: First, remove all grease and oil from the brick and plaster by using benzine. If the plaster is new or damp, the surface should be well brushed with a solution of zinc sulphate (3 lb. to a gallon of water). Use an ordinary bristle brush and allow to dry 48 to 72 hr. Any good reliable make of undercoat should now be used, and it is well to add to the first coat an elastic primer in the proportion of 1 qt. of primer to 1 gal. of undercoat. For high-class work a second coat of undercoat (not reduced) should be applied, and finally the finish coat of flat, egg-shell or gloss, as may be desired.

For the brick walls it may not be necessary to use the zinc sulphate wash, although if the walls are newly laid or are damp it will be safer to do so. If the walls are well seasoned no sulphate will be required. The undercoat first coat reduced as for the plaster should be used, and the other coats as mentioned. All the various paint manufacturers put out brick and cement paints or coatings that will give satisfaction. The two points that must be taken care of are these: First, to neutralize the alkali in freshly laid brick or plaster, and, second, to fill up the pores in the material to prevent excessive absorption of the paint. The zinc sulphate serves to neutralize the strong alkali present in all plaster and cement work, when fresh, due to the existence of lime in a hydrated condition. If an oil paint is used directly upon this material the hydrated lime will unite with the oil of the paint, forming a soap and destroying the oil. Consequently the paint does not endure. When a solution of zinc sulphate is brushed over the surface a chemical action takes place, with the formation of two new compounds. The pores of the brick or plaster become filled with these two substances which are both inert chemically, or at least they do not affect the paint. In addition, they reduce to some extent the porosity of the material. The remainder of the porosity is filled up by adding the primer to the first undercoat as directed. Forty-eight hours should elapse between all coats.

Lawrence, Mass. A. J. CALHOUN.

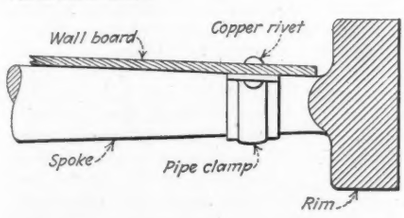
Building Maintenance and Plant Safety

The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Substantial but Low-Cost Guard for Spoked Wheels

GUARDING of spoked wheels is coming in for attention because accident records show that flywheels, pulleys and gears need to be protected so that no one can thrust an arm or a leg through them inadvertently; herein lies the risk, and the accidents resulting have usually been of the most distressing sort. There is no good argument against guarding these wheels. Neatly guarded wheels look as well as open ones and also have the advantage, with disk guards, that the fan-like action is reduced.

One substantial type of guard for spoked wheels particularly of large diameter was adopted in one plant for a number of balance wheels about 3 ft. in diameter. How these were made and applied is shown in the accompanying sketch. Disks of a size to fit inside the rim were cut from wallboard of cheap grade. This material is about ¼ in. thick and is very tough. These disks were then fastened to the side of the wheels by using ordinary galvanized pipe or conduit straps or hangers. These straps or clamps were bent slightly to conform to the spoke shape and then were copper rivetted to the wallboard disk.



Method of guarding spokes or arms of a small flywheel.

A disk of wallboard is attached to the arms of the wheel by pipe straps and copper rivets. If preferred, disks may be attached to both sides. This not only gives added protection, but also reduces the fan action of the arms.

A better, safer guard would be hard to conceive. It passes any inspection and is good for any speed. If desired, the disk could be applied to both faces and the straps dispensed with.

DONALD A. HAMPSON.

Plant Superintendent,
Morgan and Wilcox Mfg. Co. ,
Middletown, N. Y.

Convenient Method of Filing Blueprints for Easy Reference

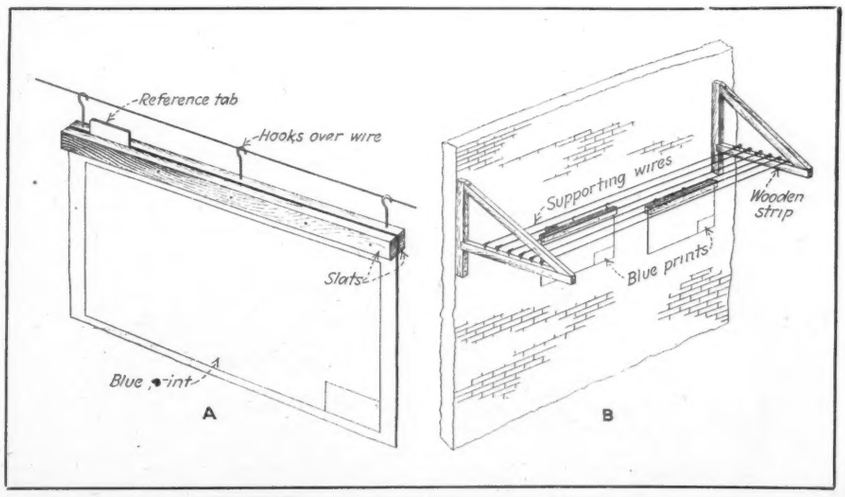
WHEN doing construction work it is often necessary to refer frequently to blueprints. However, these are hard to handle when rolled up and easily become torn. Under such circumstances I have found that the rack which is shown in the illustration affords a very convenient means of filing the blueprints in such a manner that they are protected from injury and yet can be located and referred to without difficulty.

The blueprints are nailed between two slats or thin strips of wood. Small hooks should be screwed into each end and in the middle of one of the slats. It is advisable to place a reference tab at the upper left hand of the blueprint to facilitate identification. The method of mounting the blueprints is shown in (A) of the illustration.

The rack is constructed as shown in (B). Two braces or supports are mounted on the wall, or in any convenient place. These supports should be spaced from four to six feet apart, depending on the size of the blueprints and a number of strong iron wires should be stretched tightly between them and fastened firmly.

The blueprints are then hung on the wires by means of the small hooks. It is advisable to hang all of them at one end of the rack: when a blueprint is to be examined, it can be slid over to the opposite end of the rack, away from the others.

Oakland, Calif. S. H. SAMUELS.



The blueprints are mounted between thin slats fitted with small hooks, A, and hung on wires stretched between two supports mounted on the wall, B.

Some Troublesome Problems in an Industrial Works

EVERY engineer and mechanic of experience knows that trifling things sometimes stand between success and failure. For example, recently there was brought to my attention a case of poor design, or perhaps more correctly speaking, lack of design. A bakery using a large reel oven, into which steam is injected for a certain effect on the product, experienced trouble getting results. A boiler had been installed to furnish steam for heating and process work, one of the processes being baking. The management had been assured that steam-heating pressure, of 15 lb., would be sufficient to supply steam to the ovens.

Upon starting up the boiler pressure was entirely too low to supply the steam needs of the oven. Permission was obtained from the city boiler inspection department to increase the pressure and this, of course, required a licensed fireman. Also, a costly pressure-reducing valve was installed to protect the heating system. About 60 lb. pressure was found to be necessary to furnish satisfactory service. It is evident that no serious thought had been expended on the problem. A pressure of 15 lb. was not enough; that was quite clear. What could be more simple than increasing the pressure without looking into the cause of the trouble?

An investigation disclosed that about fifteen boiler-horsepower or about 8½ lb. of steam per min. was required by the oven during the time that steam was used. The piping from boiler to oven was the equivalent of 80 ft. of 1½-in. pipe, which served as a main and a header for the oven branches, which were made up of 20 ft. of 1-in., 7 ft. of ¾ in., and 13 ft. of ½ in. piping. Just what dictated the pipe sizes was not apparent. The velocity of the necessary steam passing through the ½-in. piping would have to be 40,000 ft. a minute. The same men who connected the steam-heating radiators with 1½-in. pipe, connected the two side-inlets of the oven with ½-in. pipe and the oven takes many times the steam required by a radiator. When the piping from the boiler is changed to 2 in. (which will also serve as a header for two ovens), and the oven branches to 1 in., a heating-pressure of 15 lb. will be sufficient.

A short time ago I was asked, "Why is it that so often the recommended auxiliary equipment proves entirely inadequate for the service?" The equipment discussed (or cussed) was a bucket elevator serving a grinding mill. Upon learning the capacity of the mill and the size of the elevator, simple calculations showed that the elevator should be large enough for the job; in fact, it was larger than I would install for the service. My friend yelled, "There you go now! I tell you the elevator won't handle it! We clean chokeups every hour!"

An inspection showed that the 30-in. head-sprocket was going at 45 r.p.m. This was much too fast and so I had the elevator-head removed. This showed every up-coming bucket heaping full and, when passing over the top of the sprocket, it would heave its contents upward so that the grain would then fall down the leg or casing, with little more than a handful entering the discharge spout. Changing the drive pulley so as to get a speed of 32 r.p.m. for the head-shaft corrected the difficulty. Over- or under-speed is a common cause of trouble with centrifugal-discharge elevators.

Compressed air is often a helpful convenience and could be used more if it were but thought of in emergencies. We are all prone to think of mechanism when a material-handling, or machine driving problem arises. Reciprocating steam-pumps can be operated satisfactorily, although not economically, with compressed-air.

A rotary dryer was fitted with a spout which, because of its steep pitch, was thought capable of readily chuting the material into the dryer. As the material was fine and moist it gave trouble from the start by choking the spout. A man provided with a pole was put to work prodding the material down the spout pending the installation of a screw-conveyor feeder. About this time my attention was called to the difficulty. Finding a compressed-air line close by, we carried a ½-in. pipe into the feed spout. A cock with a counterweighted lever was rigged up so that a pin on the end of the dryer opened the cock and the intermittent air blast at each revolution of the dryer effectively cleared the spout.

A bin at this plant gave considerable trouble by the choking of the discharge opening which made it necessary for a man to hammer the hopper with a sledge to start the material flowing. A ½-in. air pipe was projected into the hopper, and with a valve within reach from the floor the "hang-ups" were brought down by a quick opening of the valve. It was found that by keeping the valve "cracked," and permitting a small amount of air to flow into the material constantly, it was aerated and flowed freely. In using compressed-air for this last purpose it should be borne in mind that the air sometimes carries considerable water which, with some materials (cement, for instance) might cause damage.

And so on, indefinitely. Looking back over years of experience, it seems that most of the troubles encountered have been like those described. The remedy is simple. One big reason why it is not applied earlier is that those associated with it too often look more at the trouble than at the possible cause and the common-place remedies which may be applied.

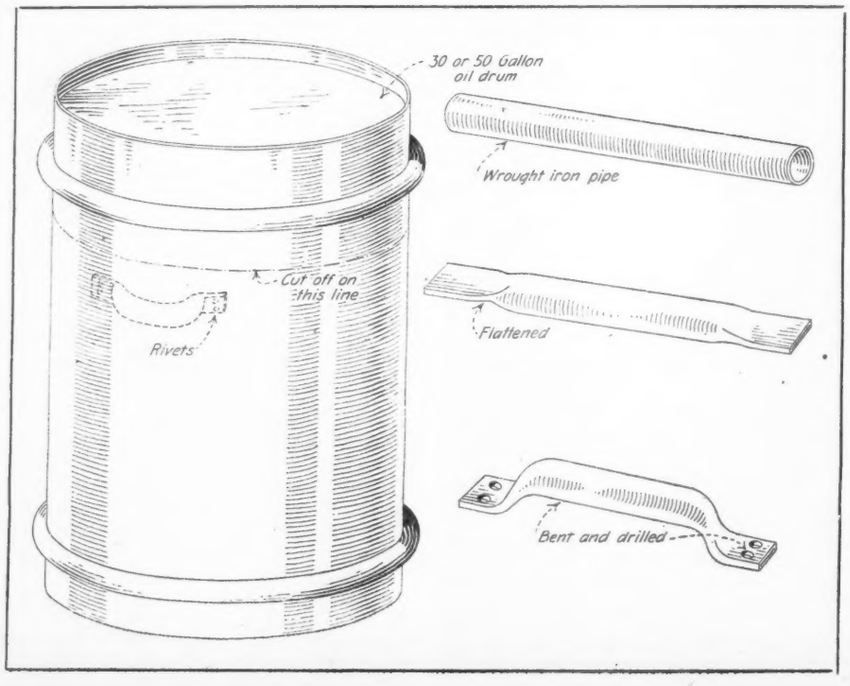
Kansas City, Mo. C. O. SANDSTROM.

Making Heavy Refuse Containers from Oil Drums

ALTHOUGH steel oil drums can usually be returned for credit, it is sometimes of advantage to use them for making special tote barrels or refuse cans for heavy material. Their special advantage lies in that they are made of somewhat stronger and heavier metal than can ordinarily be obtained in purchased refuse containers. For convenience they should be fitted with handles made of sections of wrought-iron pipe with the ends flattened out, bent and drilled as shown at the right in the sketch. These handles are riveted as shown.

The top section of the barrel may be cut off at any point, but it is usually best to cut it below the bulge, as indicated in the drawing. If these containers are to be used for very heavy material the barrel may be cut in two in the middle and made into two containers of equal size and the handles attached lower down.

Washington, D. C. G. A. LUERS.

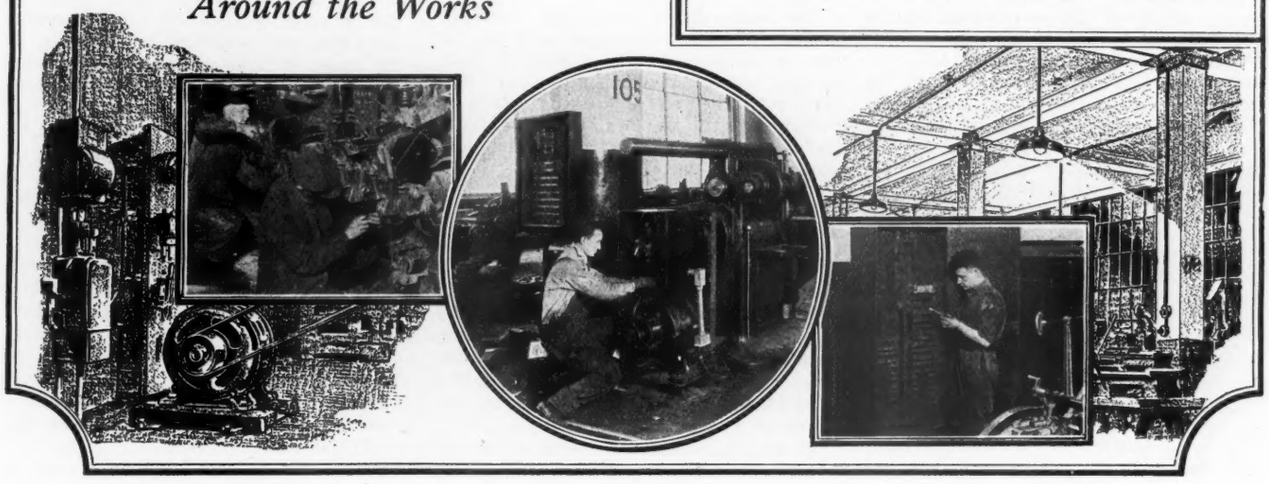


Extra heavy refuse containers or tote barrels may be made from oil drums by cutting off the ends and riveting on handles.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Method of Grounding Circuits to Protect Maintenance Men

IN A paper on safe operating practice with regard to electrical devices, presented at the Safety Congress recently held at Louisville, Ky., G. F. MacWilliams, electrical engineer of the Pennsylvania Coal & Coke Corporation, Cresson, Pa., spoke of the importance of grounding and short circuiting supposedly dead circuits before attempting work on these circuits. Mr. MacWilliams had the following to say in connection with this subject:

"Ground connections should be made to provide safety to equipment, discharge of abnormal potentials, and for providing a path for current leaks from equipment. Such means will reduce the hazards accompanying the operation of electrical apparatus. Sometimes it is not feasible to ground electrical apparatus and by doing so the hazards to the operator are increased rather than decreased. In any case, the grounding of equipment supports, etc., must be understood to be done for the protection of the operator from shock should these parts become charged without the operator's knowledge.

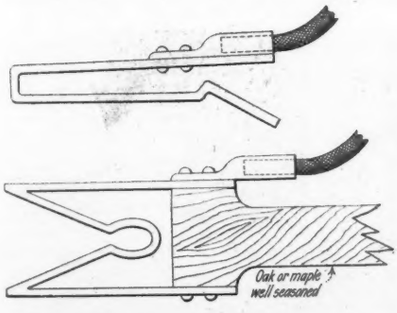
"Grounded frame parts will increase the danger of shock to the operator should he make contact between current-carrying parts and grounded frame parts.

"If oil switches were designed so that it would be necessary to open the switch before a short circuit or ground could be applied, a great step toward protection of operators would be accomplished.

"In short circuiting and grounding compartment-type switches, the ground connection should be made first. If the doors on the compartment are hinged at the top, do not remove them but swing them forward sufficiently so that you can reach by them and apply the connection to the switch. By this procedure the door will act as a barrier in case the switch is charged when it was thought to be dead.

"When men are working on lines, the conductor should be grounded and short circuited. The ground connection should be made first, and the short-circuiting devices applied afterwards. This should be done whether the work is to be performed inside the plant or outside on the line. For this purpose flexible cable not smaller than No. 6 should be used. For station work, one end of the cable should be fitted with a clip, as shown in the accompanying diagram which hooks over the ground bus and locks in place. On the other end of the cable a set of spring clips fitting the contacts on the line terminals and mounted on wood handles should be used. For grounding outside line wires a piece of ¾-in. pipe should be used not less than 5 ft. long with a connection head on one end and a point on the other.

"A clip that is similar to the one shown in the lower part of the accompanying diagram, made of copper and mounted on wood handles should be used for attaching to the line wires."



These clips are used for making ground connections to lines before maintenance work is started on the lines.

The upper clip is made to hook over the ground bus and is connected by No. 6 flexible cable to the lower clip which is hooked to the line wire or disconnect switch.

Motor Inspection Form Helps in Training Inspectors

NO ONE who has had any experience in inspecting equipment will deny that it is dirty and oftentimes disagreeable work. It requires a man who has judgment, brains and persistence. Such men are not easy to find. Also, it is not always good policy to turn even a good man, particularly one who is new to the plant, loose on a job and trust to him to inspect everything that should be looked after. It is very easy for an inspector to overlook certain pieces of equipment or elements thereof—and it is human nature to

Form 1094

INSPECTORS SHEET

Motor No..... H. P..... Bldg..... Floor..... Date.....

Inspected by..... Approved by.....	Yes.....	No.....
Has Motor been oiled?.....	Yes.....	No.....
Has Motor been cleaned?.....	Yes.....	No.....
Are Oil Rings turning and carrying oil?.....	Yes.....	No.....
Are Bearing Bolts tight, Pulley end?.....	Yes.....	No.....
Are Bearing Bolts tight, Commutator end?.....	Yes.....	No.....
Is Pulley tight on shaft?.....	Yes.....	No.....
Does Belt run straight?.....	Yes.....	No.....
Are Field Leads well insulated?.....	Yes.....	No.....
Does Field Coils need painting?.....	Yes.....	No.....
Does Armature need painting?.....	Yes.....	No.....
Air Gap between Armature and Topfield Pole?.....	Yes.....	No.....
Air Gap between Armature and Bottomfield Pole?.....	Yes.....	No.....
Does Commutator spark?.....	Yes.....	No.....
Are Brushes short?.....	Yes.....	No.....
Are Brushes shunted?	Yes.....	No.....
Are Brushes parallel with Commutator Bars?.....	Yes.....	No.....
Are Brush Holders properly spaced?.....	Yes.....	No.....
Is Brush Tension correct?.....	Yes.....	No.....
Are all Wires properly taped?.....	Yes.....	No.....
Are all Terminals tight?.....	Yes.....	No.....
Are Fuses right size? Put down size.....	Yes.....	No.....
Is Switch in good condition?	Yes.....	No.....
Does Rheostat Handle release?.....	Yes.....	No.....
Are Rheostat Contacts burned?.....	Yes.....	No.....
Does Starting Apparatus need attention?.....	Yes.....	No.....
Are all Wires in good condition?.....	Yes.....	No.....
Is Oil clean in Auto Starter?.....	Yes.....	No.....
Does Auto Starter Handle release?.....	Yes.....	No.....
Does Auto Starter Handle hold over?.....	Yes.....	No.....
Is Auto Starter grounded?.....	Yes.....	No.....
Is Motor grounded?.....	Yes.....	No.....
Are Drum Contact burned?.....	Yes.....	No.....
Are Finger Contact burned?.....	Yes.....	No.....
Does Controller need attention?.....	Yes.....	No.....
Is Controller grounded?.....	Yes.....	No.....
Does Oil Breaker need attention?.....	Yes.....	No.....
Location of Oil Breaker or Switch R. S. R.....	.....	
111 Shed.....	.....	
Burritt Sub. Sta.....	.....	
Dept. 300.....	.....	

This sheet helps the motor inspector by showing him just what to do. It also serves as a valuable record of the condition of the equipment.

slight the more difficult or disagreeable parts of a job.

We have drawn up the motor inspection form shown in the illustration to help us train our inspectors in the work; also to help the inspectors to do a good job. As will be seen, this form covers about all the points that should ordinarily be checked during the inspection of a motor so that little or nothing is left to the memory of the inspector. As each item is gone over, the inspector puts a check mark in the Yes or No column. When the sheets are turned in to the maintenance department, we have a very good record of the condition of the motor and its auxiliary equipment.

As inspectors we select men who have good, common sense and are thoroughly honest and give them these sheets to help them to know what to look for. With the help of these forms and such instructions as may be necessary or advisable to give them we have found that it requires only a few weeks to make a good inspector.

Power Engineer,
The Stanley Works,
New Britain, Conn.

C. H. HART.

Method of Locking Compensator Handle to Prevent Starting Motor

THE device shown is used by the Canada Cement Company, Ltd., Montreal, Canada, to lock the operating handle of a compensator so as to prevent starting the motor while someone is working on the drive or the driven machine.

As can be seen, the device consists of a small piece of sheet steel and a wooden arm which is hinged to the support holding the compensator. The wooden arm is slotted as shown in the right-hand illustration so as to receive a metal plate, which metal plate has drilled in it one large hole that fits over the handle of the compensator. In addition there are several small holes, into which padlocks may be locked, as shown in the left-hand picture.

To make the wooden arm stronger and to prevent wear, one side of the slot is reinforced with a slotted plate as can be seen in the right-hand illustration. The metal locking plate is fastened to the wooden arm by a chain, so as to prevent it from being lost when not in use.

This locking device for a compensator can be very easily made and installed.

The construction of this device is shown in the two illustrations, which were furnished by the National Safety Council. Note that the device will accommodate four locks; thus as many as four men or gangs may be working on the motor, drive or machinery driven by the motor and there will be no danger of the motor being started until each of the four men or gangs have completed their work and removed their individual lock.

Designating Fuse Capacities by Different Colors

THOSE who are engaged in electrical maintenance work know by experience that machine operators are, as a rule, not familiar with fuse capacities. To them a fuse is a fuse, and if a cartridge fuse fits the clips, they assume that it is the proper size.

It is advisable to have machine operators practice a "hands-off" policy on electrical equipment of all kinds unless conditions are such that the operator can save time by replacing blown fuses. Then he must know what he is doing.

Frequently, there are times in all industrial plants when a fuse is blown by too rapid starting of a motor, or through other causes, and when the operator notifies the electrician he is unable to give the capacity of the fuse. If the plant is so large that the electrician can not remember the capacity of each fuse he must either take a supply of different sizes with him, or else go to the blown fuse to ascertain the capacity and then go back to the supply room to obtain a fuse of the proper capacity.

A fuse identification scheme which is very convenient involves painting a colored stripe or circle near the clips of all motor or other fuses, the fiber tubes of the corresponding fuses being painted the same color. When a fuse blows it is then a simple matter for the operator to call the electrician and tell him that a "yellow fuse" has blown.

The following color scheme is used in one plant which operates at 250 volts and covers all of the usual sizes used in a plant of this kind:

For 0-30-amp, ferrule type cartridge fuses:

5 amp., white—called Little White.
10 amp., black—called Little Black.
15 amp., blue—called Little Blue.
20 amp., green—called Little Green.
25 amp., red—called Little Red.
30 amp., yellow—called Little Yellow.

For 31-60-amp. ferrule type cartridge fuses:

35 amp., white—called Big White.
40 amp., black—called Big Black.
45 amp., blue—called Big Blue.
50 amp., green—called Big Green.
55 amp., red—called Big Red.
60 amp., yellow—called Big Yellow.

Some plants may not make use of all of the fuse capacities shown, but this tabulation gives a general idea of the scheme, which should be worked out to suit the conditions. For instance, a 110-volt installation would use larger-capacity fuses for the same power delivered, while a 440-volt installation would use smaller fuses.

This color scheme also serves as a check whereby the head of the department can see that the proper size of fuse is being used, simply by comparing the color of the marking stripe or circle with the color that has been painted on the fuse.

When renewable fuses are being used it is imperative that the proper-size links be placed in the different-colored holders. A renewable fuse of the Federal type with the capacity marked and in plain view at all times, even though the fuse is in the clips, lends itself admirably to a cross-check by the color scheme.

Plattsburg, N. Y. A. W. OPPMANN.

Method of Handling Installation of New Switchboard

DUE to the increased power demands, it recently became necessary for us to rearrange the power lines and install a new switchboard. Inasmuch as this was a job of considerable magnitude the manner in which the work was handled may be of general interest.

The old switchboard was in an unhandy place, being near a Corliss engine flywheel; also, it was not complete,

having no meters of any kind, no overload relays, no bus-bars or suitable switches, and no capacity for additional feeders.

It was built of a few 3-in. wooden strips on which were mounted a limited number of porcelain cleats to hold the small-sized feeders, some single-pole cutouts, and some loose-hinged, 100-amp. three-blade switches. In short, it was too small and unsafe.

With the old arrangement the conductors were carried up through the roof in conduit, and thence to the various other buildings on low wooden horses. Many new motors were to be installed, and lighting lines re-arranged, so it was deemed necessary to provide a better outlet for the increased number of lines coming from the new switchboard.

The new switchboard, shown in the illustration, was designed and completely built by the General Electric Co., even to wiring the goose-neck lamps on all of the upper panels. We had in stock no material from which to construct such a board; besides our electrical force was too busy with daily maintenance and repairs to do more than to assemble the switchboard, when received.

The initial cost of the switchboard was considered only on the basis of capacity, efficiency, and completeness. We specified that it be shipped complete for assembling by our electricians, as it was desired to operate it immediately upon erection. When we were making the plans the management issued a simple "cast-iron" warning that no complaint as to incompleteness or inefficiency was to be voiced by anyone, superintendent, chief electrician or electrical workers, after the installation of the board, as it was desired to have the job done up properly once for all time.

It was specified that generous sized bus-bars, oil switches of 200-amp. capacity and terminal lugs be provided to care for loads likely to be carried for at least five years ahead. It was also specified that there should be no live parts on the front of the power panels of the 440-volt system, that overload protection be afforded by time-limit relays, that only two circuits be connected to each power panel, and that every power circuit have only one ammeter in its three-wire, three-phase line.

The panels were to be built down to the floor, the lower ones to take wattmeters later on.

The new board is 18 ft. long and 6 ft. 4 in. high, with panels 2 ft. wide. It is set 4 ft. from the wall, and all power and light lines are carried straight up through an opening in the roof and into a frame wire-tower, from whence they extend in different directions to the various buildings and other departments. Arms are used on the corners of buildings, thus eliminating the wooden horses.

Current is purchased at 13,000 volts and is stepped down to 440 volts for the motors, and again stepped down through smaller transformers to 110 volts, three phase, for lighting.

The first right-hand panel is for 110-volt, three-phase a.c. lighting. The last two panels to the left are for 125-volt battery charging, one of the panels controlling a belt-driven generator and the other a synchronous motor-generator set. These panels can be coupled with an equalizer to care for a total load of 800 amp. at 125 volts.

The second panel from the right carries the main power oil switch, which connects directly to the bus-bars, thus providing a quick and handy means of shutting off all power in an emergency.

The third panel from the left carries the synchronous motor starting switch and compensator. All the intermediate panels are for 440-volt power, and have two a.c. ammeters, two sets of overload relays, two 200-amp. oil switches, and one pilot lamp.

A ground detecting voltmeter with a testing plug is provided on the fourth panel from the left, so that ground readings may be taken on all three phases of the power lines.

Overload time-limit relays are used on the power panels, and fuses on the lighting panel. The power circuit ammeters are connected to small instrument transformers set in line with the copper feed bars between the oil switches and the main busbars located above.

The five motor feeder panels have a total capacity of 1,000 h.p. at 440 volts. The lighting panel, at the extreme right, carries six, three-wire switches with a total capacity of 600 amp. at 125 volts.

Each lighting switch has a capacity of 100 amp., and each power switch will carry 100 h.p. Many lines that were formerly carried along the ceiling of departments adjacent to the engine room have been turned up into the tower and are run out-of-doors, so as not to take up needed room inside the building. The lighting lines are No. 6 and No. 00. Many of the power lines are No. 4 and No. 4/0. The 125-volt d.c. cables to the storage battery department are 300,000 circ. mil, as are the 440-volt main feeder cables from the transformers. Weather-proof and rubber-covered wire is used over the roofs, and white slow-burning up into the wire tower.

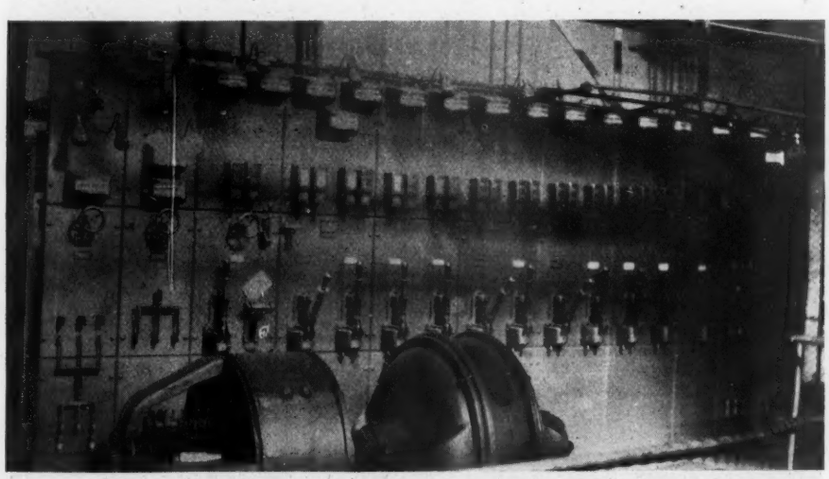
The whole switchboard frame is grounded by a No. 4/0 conductor carried out through the engine room wall, to an alley where the ground is very moist, and there bolted and soldered to two copper plates each 2 ft. long and 1 ft. wide, buried in a barrelful of coke some 5 ft. under ground.

As the switchboard stands, it has reserve capacity for years to come, looks very neat, is strongly built and practically fireproof, slow-burning wire being used at the rear. It is handy and safe to operate, takes automatic care of overloads, and has plenty of room for a worker to make the required connections at the rear.

The price of its installation was never regretted by our company, as no expense was spared to make it electrically perfect and with sufficient capacity.

New Britain, Conn. H. S. RICH.

New switchboard, designed for ease in making future extensions, which replaced an obsolete installation.

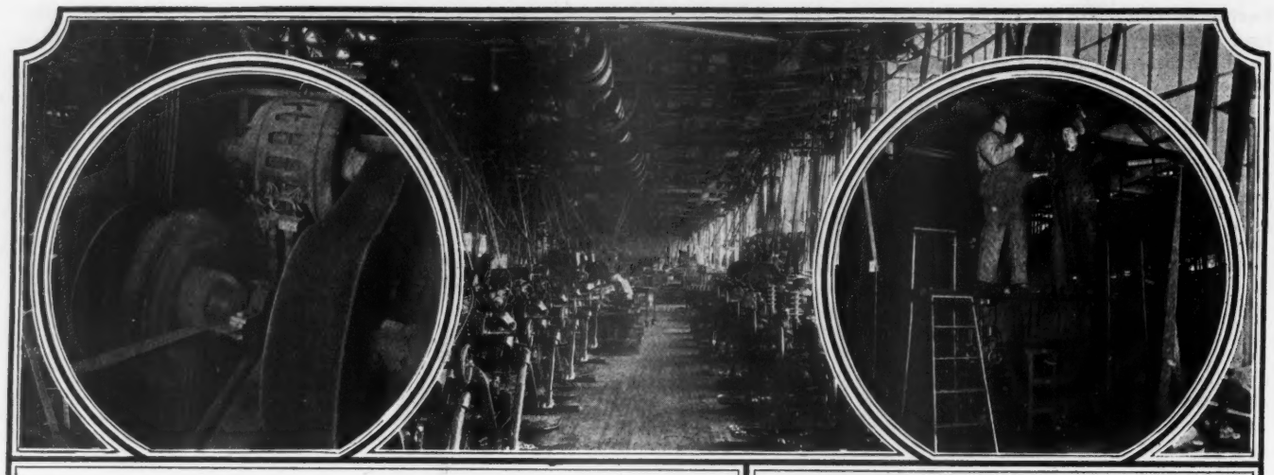


Routine for Handling Fuse Renewals on the Night Shift

IN A PLANT which covers a large area and operates 24 hr. a day, only one or two electricians are maintained on the night shift. It frequently happens, however, that a fuse must be changed during the night. As it often requires some time to locate these electricians at night, in case of an emergency, the foreman of each department is instructed on how to change a fuse and is provided with a supply of fuses of the various sizes required. To aid him in selecting the right size of fuse, there is stenciled on the front of each fuse box the ampere rating of the fuse to be used.

In addition to this, the foreman must in each case report the fuse removed and its location. Members of the electrical department on the day force immediately check up on each fuse so reported to be sure that the correct size is used. While there may be some objection to this method of handling fuse renewals, it has the justification that it is necessary to make renewals quickly so as to get the machine in operation again as soon as possible, as this is a continuous process.

Chicago, Ill. E. B. F.



Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Increasing Size of Mounting for Larger Motor

SOMETIMES, because of an increase in production or difference in material handled, it is found necessary to replace a motor with one of a larger size.

If the machine has a bed plate built for only one size of motor, the task of putting in a larger motor may be somewhat troublesome.

In the accompanying illustration of a machine for charging pipe into a welding furnace, it was found that in charging the larger sizes the motor was too small to push the pipes into the furnace fast enough. The motor then in use was a 15-hp. series-wound, mill-type motor.

The gear ratio between the motor pinion and the gear on the countershaft was changed, but this increased the load on the motor and lowered the speed still more. Hence, it was decided to replace the 15-hp. motor with a series-wound, mill-type motor rated at 27 hp.

The charging machine bedplate for the motor was not large enough to take the 27-hp. motor; so a 1-in. steel plate, large enough to receive the new motor, was drilled to fit the drilling plan of the new motor, and then placed on the old bedplate, as shown in the accompanying illustration. This plate was drilled to line up with the holes in the old bedplate, these holes were countersunk and the plate bolted down. The motor was then mounted on the new plate. The arrangement has so far worked satisfactorily for three years.

Indiana Harbor, Ind. H. W.

A 27-hp. motor replaced a 15-hp. motor on this pipe charger.

The mounting built into the machine was not large enough to accommodate the new motor; so a sub-base large enough to take the new motor was made of 1-inch steel plate. This was bolted to the old mounting as is shown in the illustration.

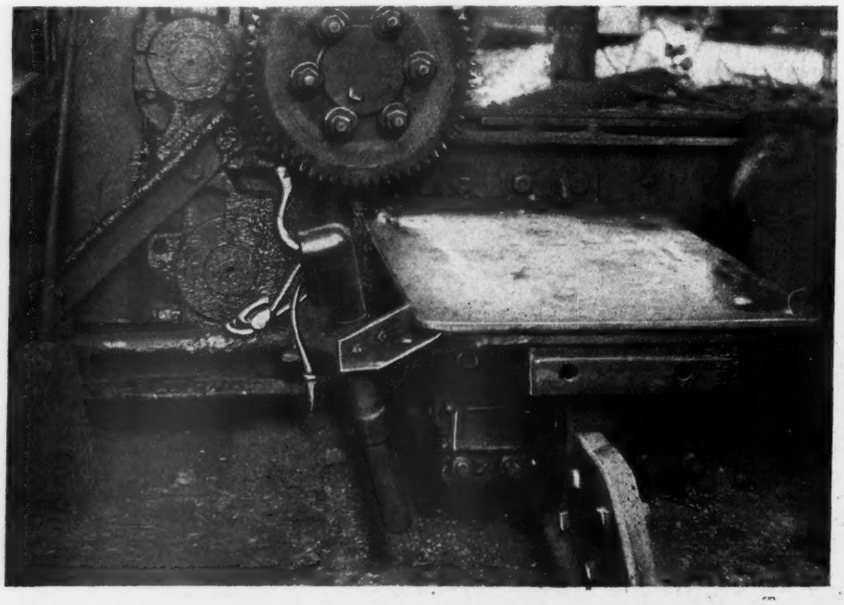
Precautions Necessary in the Use of Babbitt

IN THE purchase of babbitt metal, the purposes for which it is to be used should always be given or, better still, the proportion of antimony, lead and copper should be specified, if the buyer is thoroughly acquainted with the manufacture of this metal and knows what composition to use for given service conditions. For example, greater compressive strength is called for in heavy machinery than in line-shafting, light mill, and shop machinery. In the first case 80 parts of tin, 10 of antimony, and 10 of copper is a good proportion. In the latter case an alloy composed of 50 parts of tin, 25 of lead, and 18 of antimony gives good service.

Due regard for speed must be taken into consideration in the case of light bearings, but this is not so important in the heavier types, where the compressive strength is of first importance. Some engineers think that the quality of a babbitt metal is influenced by the order in which the components are added, but from authoritative tests which have been made, this has been proved a fallacy.

When babbitting a bearing the following instructions should be followed in order to obtain the best results:

In the case of a cast-steel or cast-iron shell, all old babbitt must be removed; this is best done by heating, then dipping in lye to remove dirt, and finally scraping off all rust and oxidation. Tinned shells of bronze or cast iron should be cleaned by heating in a pot of molten babbitt and when the old metal has melted out the tinned surface should be painted with a soldering flux and retinned by dipping in solder at about 650 deg. F. The portions which are not to be tinned should be painted with a thin mixture of clay and water. The shell to be tinned should be left



in the solder long enough for the solder to run off, leaving a thin coating; then flux the surface again and give another dip into the molten solder. Should there be any untinned patches left the operation must be repeated.

Babbitt should not be used for tinning, because the higher temperature makes it hard to hold a thin skin of metal on the shell.

It is not advisable, unless absolutely necessary, as in case of a breakdown, to babbitt a bearing directly on the shaft, as the latter may be sprung. Therefore a mandril is used. This is heated to about 350 deg. F. and washed with a thin, clay-and-water solution, which dries off leaving a fine dust that gives a good surface to the bearing. The shell must be preheated not more than 200 deg. F.; otherwise it takes too long to cool and the heavier components of the babbitt will settle, making a bearing that is soft at one end and brittle and hard at the other.

Babbitt should be heated slowly and stirred at frequent intervals, adding graphite or charcoal to stop oxidation, and must be skimmed before using to insure that no scale or slag gets into the work. The average temperature at which the metal should be kept is around 865 deg. F., but this varies with different brands of babbitt.

In order to do a good job of babbitting, it is necessary to have clean tools, to preheat to the proper temperature, to have a well-tinned surface, and to maintain the metal at the correct temperature. The molten metal should be poured in a steady stream down the mandril, to avoid air spaces, using a ladle with a round spout, in preference to a narrow, sharp one.

In the case of heavy bearings, where there is a considerable thickness of metal to be poured, the shell should be dovetailed out or suitable anchorage provided, and should be tamped with rods while pouring.

When a bearing is poured directly, instead of having a shell, the above instructions will apply, but care should be taken to make provision for anchoring the babbitt to the bearing.

MAURICE C. COCKSHOTT.

Los Angeles, Calif.

Selecting Motors for Machines That Require Flywheels

IT FREQUENTLY happens in a shop using drawing presses, rolls, or other machines requiring flywheels, that the first motor application is unsatisfactory. In many such cases trouble has been experienced by the breaking of gears or other parts of the driven machine and in some cases the motor has been damaged or has had to be replaced with a larger or different type of motor. The majority of troubles of this sort come from the fact that full consideration has not been given to the special conditions existing with flywheel installations.

Machines having a duty cycle consisting of a short period of heavy load, followed by a period of light or idle load, use flywheels to deliver energy to the machine during heavy loads and to recover this energy from the motor during the period of light load. In order that the flywheel may deliver its energy to the machine it must be slowed down slightly and the energy thus delivered will be recovered as the motor brings the flywheel up to speed during light load. If a standard, constant-speed motor is used on such drives the results are often unsatisfactory. The motor running at constant speed does not allow the flywheel to deliver its energy to the machine, with the result that all the energy for the peak load must come from the motor and the supply line. This condition results in overheating the motor, excessive surges in the supply line, and often injury to the machine. On the other hand, a slight reduction in speed at the time of peak load has a cushioning effect upon all parts of the machine and greatly reduces the strains.

The unsatisfactory conditions outlined above may be eliminated by using a motor with more than the standard amount of resistance in the rotor circuit. In the case of squirrel-cage motors this may be accomplished by replacing the standard rotor with a high-resistance rotor, or by replacing the entire motor. The high-resistance rotor gives off more heat than the standard rotor and this condition must be taken into account if the rotor only is changed. It is generally better to replace the entire motor. The high-resistance motor may, in many instances, be of less horsepower rating than the standard motor and yet perform its work more satisfactorily. With slip-ring motors it is only necessary to connect some extra-heavy-duty resistors into the rotor circuit permanently in order to get the result desired. The writer has found many cases where a smaller motor with proper rotor has replaced a larger standard motor. In the case of direct-current motors the ordinary shunt motor can often be advantageously replaced with a compound motor so that the speed characteristics will be such as to allow the flywheel to do its share of the work.

A recent practical application of this problem was brought to the writer's attention when a 750-hp., slip-ring motor on a rolling-mill drive behaved unsatisfactorily. A standard, constant-speed motor had been furnished and no account taken of the requirements of the flywheel. The result was that during the first few weeks of operation several machine parts were broken and the power company complained of severe power surges on the line supplying the plant. A suitable amount of heavy-duty resistance was permanently connected in the rotor circuit and the power surges were reduced from 1,250 hp. to 750 hp., while no further trouble was experienced from broken machine parts.

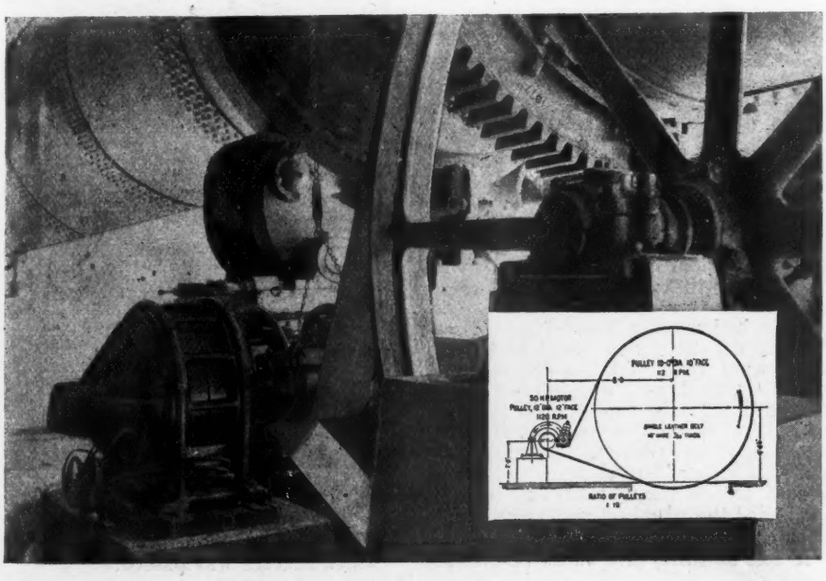
DEAN W. TAYLOR.

Power Engineer,
Central Indiana Power Co.,
Indianapolis, Ind.

Driving Belts on Short Centers With High Pulley Ratios

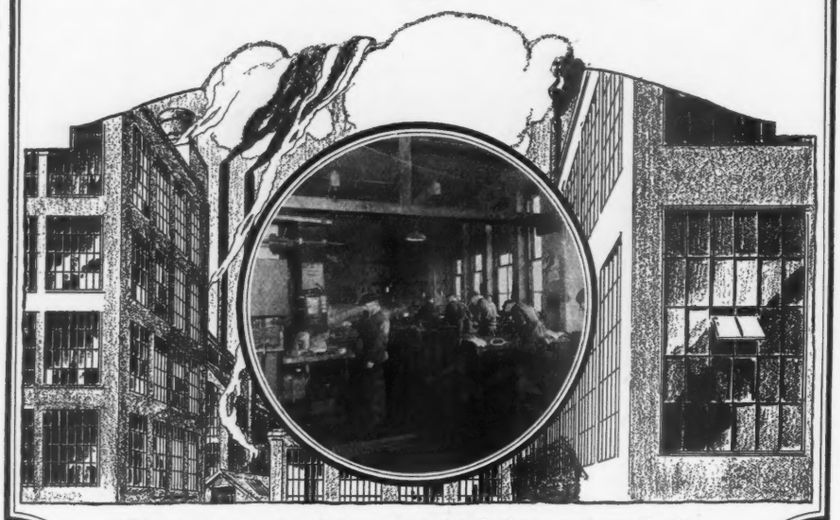
ORDINARILY large pulley ratios mean long belts with a wide pulley center distance. Even then if the pulley ratio is very large, such as the 10-to-1 ratio shown in the accompanying illustration, the necessary center distance will be so long that the belt will flop. Also, the small amount of belt surface in contact with the driving pulley will require some form of tension device to keep the belt tight enough to operate.

In the illustration a 10-to-1 ratio is obtained on short centers through the Lenix drive, as shown. This drive operates a Portland cement rotary kiln, 24 hr. a day under severe temperature conditions. Here a single 10-in. leather belt connects the 12-in. pulley on the 50-hp. motor to a 120-in. pulley on the drive of the kiln. Since the drive maintains its proper tension at all times irrespective of how the belt is affected by temperature conditions and also gives an increased arc of contact on the driving pulley, the life of the belt is not shortened either by slipping or by stretching through excessive tension. The special idler pulley may be raised when the drive is not operating, thus reducing the tension.



This rotary kiln drive operates with a 10-to-1 pulley ratio on an 8-ft. center.

In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

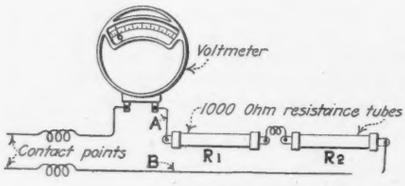
Defective Armature Testing Equipment Gave Puzzling Results

CONNECTIONS of a voltmeter and resistance used for making the bar-to-bar test on armatures in the course of production, are shown in the illustration. The test consists in passing current through the armature and taking, by means of the voltmeter, the drop from bar to bar all around the commutator. If all armature coils are alike and the commutator is faultless, all drops will be the same. A short-circuit will cause a small deflection or no deflection at all, according to whether the short-circuit is in the coil or in the commutator. A poor connection will cause a larger deflection and an actual open-circuit will throw the meter needle off the scale. The two 1,000-ohm resistance coils were used to hold normal deflections to a readable value.

In testing a certain series-connected, 4-pole armature, every contact with the commutator would throw the needle of the meter clear off the scale. In order to find out whether or not all abnormal deflections were of the same value, the current through the armature was greatly reduced; the deflections were then of uniform value. This meant that the trouble must be something unusual, such as a wrong connection that would convert the winding into a re-entrant winding, thereby placing several coils in series between every pair of commutator bars. Lifting several leads on opposite sides of the commutator and ringing out showed, however, that the connections of the coil leads to the commutator were counted off correctly. At this stage the electrician became interested and, in order to get all information first-hand, put the armature back into the bar-to-bar testing rack. Much to the surprise of everyone concerned, all deflections were now perfectly normal for that type and size of armature.

Investigation disclosed that the two resistance tubes (R_1) and (R_2) had become turned end for end in such a manner that wires (A) and (B) were touching, thereby cutting both of them out and placing the voltmeter directly across the testing leads.

Brooklyn, N. Y. J. A. HORTON.



A short-circuit between wires A and B cut out the resistance tubes and caused the voltmeter to indicate an open-circuit in all coils of an armature under test.

Unique Method of Heating Locomotive Wheel Tires for Removal

RECENTLY we had to turn some locomotive wheel tires which were badly worn and had several hard spots, but were still too good for the scrap heap.

This had usually been done by setting up the drivers in the lathe just as they were taken off the locomotives, and turning them, which process required five or six days. With the idea of cutting down the time taken to do the job, the tires were heated by the current induced in them from a coil placed around the wheel. This heating expanded the tires sufficiently to enable their removal.

A coil of thirty-five turns of No. 00 rubber-covered cable was wound and taped together as shown, a layer consisting of six turns, making the coil about 5 in. wide.

The form used for winding the coil was an old 44-in. pulley set up on a small shaft across a pair of horses, so that it was free to revolve; to give the right width and form to the coil several U-shaped brackets, made of ¼-in. by 1-in. flat iron were used. These brackets were spaced equally around the circumference of the pulley and with their backs to it, being held in place by the bottom layer of cable.

The coil was then tied with heavy cotton tape in about a dozen places to make it hold its shape, as it had to be used for taking off several sets of tires.

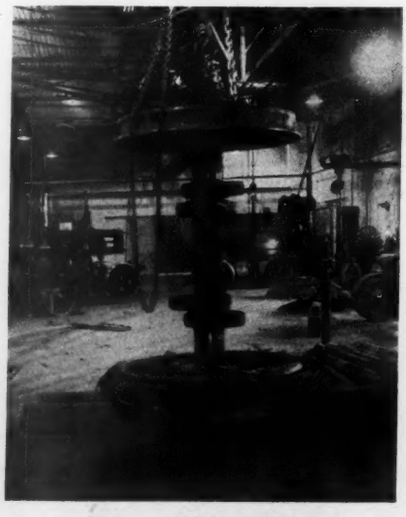
A. C. power was taken from two of the cables of a 100-hp. 550-volt compensator. A water rheostat was put in series in the circuit to control the current and a clamp-type current transformer with a 250-amp. range ammeter indicated the current used.

In operation, the driver was suspended on end with chain blocks as shown, so as to hold the lower wheel about a foot above the floor. The coil was held up around the tire as shown, blocks of wood being placed underneath to support it, and also to catch the tire when it came off and thus prevent the projecting outside rim from possibly grounding on the cable.

The coil had been made of such a size as to allow about ½ in. space between it and the tire; this space was packed with ¼-in. soft sheet asbestos to protect the insulation from the heat.

We found that a current of about 175 amps. applied for 40 min. expanded the tire enough so that it could be taken off by using a sledge and gradually raising the drivers with chain blocks.

This was a first experiment, but I am now convinced that if fifty or more turns had been used instead of thirty-five the tires could have been taken off much more easily, as they would have heated and expanded more rapidly, thereby communicating less heat to the



The tires were heated by induction, by placing the wheels within a coil of heavy insulated wire through which current was passed.

wheel and not causing so much expansion of the latter.

After the tires were taken off they were turned on a boring mill in about 10 hours., or one-sixth of the time required to do the job in a lathe.

The same method can be used when putting the tires back on, and less heat is necessary as the wheel is not heated at the same time as the tire.

J. H. GALLANT.

Canada Cement Co., Ltd.,
Belleville, Ont., Can.

Rewinding Motor for Speed and Voltage Charge

AN INSTANCE of where both a speed and a voltage change were made in a motor came up recently, and readers of INDUSTRIAL ENGINEER may be interested in knowing how the change was handled. A Westinghouse, type CCL, 40 hp., three-phase, 220-volt, 720-r.p.m. motor burned out and the owner desired to have it rewound for 900 r.p.m. and to be used on 440 volts, increasing the horsepower as much as possible.

The stator had 150 slots and the original winding consisted of 150 coils of twenty-four turns each of one No. 14 d.c.c. wire, five coils per group, connected ten-parallel delta.

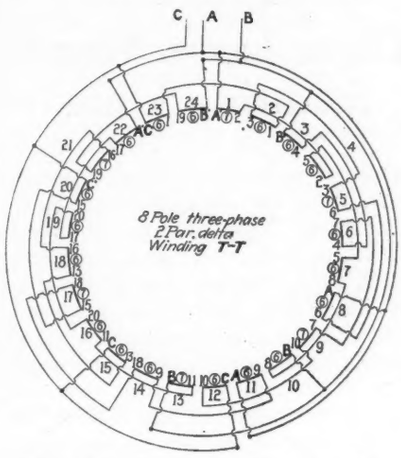
In attacking the problem the 900-r.p.m., 440-volt winding was considered as a voltage change as follows: The 720-r.p.m. series-delta voltage would be $220 \times 10 = 2{,}200$ volts and with the same number of turns per coil the series-delta line voltage for the 900-r.p.m. winding would be $(900 \times 2{,}200) \div 720 = 2{,}750$ volts. Now with 150 coils and eight poles there would be an odd grouping, or eighteen groups of six coils per group and six groups of seven coils per group, arranged as follows: 7-6-6, 6-7-6, 6-6-7, 6-6-6, 7-6-6, 6-7-6, 6-6-7, 6-6-6.

Then the only connections possible without killing or cutting out any coils are the series and two-parallel and to get a line voltage of 440 volts with a two-parallel delta connection, the series-connected winding would have to be good for 880 volts. The turns per coil for a series-delta, 880-volt winding would be $(880 \times 24) \div 2{,}750$ equals 7.68 turns per coil. An eight-turn coil could be used and the chord factor changed to reduce the effect of the 0.32 extra turn per coil.

The ten-pole full pitch is $150 \div 10 = 15$, or 1-and-16, and the 1-and-13 pitch is $11 \div 15 = .73$ or 73 per cent pitch. The chord factor of the 1-and-12, ten-pole pitch is 180 deg. $\div 15 = 12$ deg. The sine of $(11 \times 12$ deg.$) \div 2 =$ sin 66 deg. or .91354. Then 73 per cent pitch for eight poles equals $(150 \div 8) \times .73 = 12.6875$ or the chord factor of the 1-and-13 pitch will be $150 \div 8 = 18.75$; $180 \div 18.75 = 9.6$ deg. Then $(9.6$ deg. $\times 12) \div 2 = 57$ deg. 36 min. and the sine of this equals .84433.

The eight-turn coil, series-delta, 900-r.p.m. line voltage should be $(8 \times 880) \div 7.69 = 915.45$ volts, and with the 1-and-13 pitch the voltage would be $(0.84433 \div 0.91354) \times 915.45$ equals 835.8 volts. The 1-and-14 chord factor would be $(13 \times 9.6) \div 2 = 62.4$ deg., or sin 62 deg. 24 min. equals .8862 and the line voltage would be $(.8862 \div .9135) \times 915$, equals 887.64 which is alright.

The turns per coil have been reduced to eight or one-third the original; the copper should be increased three times, or the new coil can be wound with eight turns of three No. 14 d.c.c. wires in parallel, pitch 1-and-14, connected two-parallel delta for 440 volts. The diagram shows the connections.



Connections and grouping of coils in motor which was rewound for combined speed and voltage change.

The horsepower rating at 900 r.p.m. will be $(900 \times 40) \div 720 = 50$ hp. The motor will then draw 64 amp. per terminal.

The new data will, therefore, be 50 hp., three phase, 60 cycles, 900 r.p.m., 840 r.p.m. full load, 440 volts, 64 amp. per terminal. There will be 150 coils of eight turns of three No. 14 d.c.c. wires in parallel per coil, pitch 1-and-14, connected two-parallel delta.

Pittsburgh, Pa. A. C. ROE.

Simple and Efficient Device for Undercutting Mica

THE necessity of undercutting the mica of commutators on certain types of machines is well recognized and a number of devices have been brought out for this purpose. However, the price of an undercutting machine that can be adapted to all conditions is oftentimes more than a small repair shop can afford to pay. For this reason the device described below was built in one shop, and although inexpensive, it has given good service.

This undercutting outfit consists of a ⅛-hp. motor, which could be either a.c. or d.c., depending on the current supply, a flexible shaft with a 3-jaw chuck attached and a milling cutter.. The accompanying illustration shows the apparatus assembled and gives a good idea of the flexibility of the shaft, also the ease with which it may be handled. The shaft shown here was purchased from the Stowe Mfg. Co., Binghamton, New York. It is encased in a heavy leather sheath and may be operated in almost any position desired. Therefore, it is rarely necessary to remove any of the brush mountings, even on the smaller motors, during the operation of undercutting.

The chuck is simply a 3-jaw drill chuck and will be furnished and attached by the manufacturer of the shaft in accordance with your specifications. The milling cutter is a duplicate of those used by dentists and may be purchased from Ransom & Randolph, Toledo, Ohio, in various diameters and widths of teeth. The cost of the outfit complete was approximately $30.

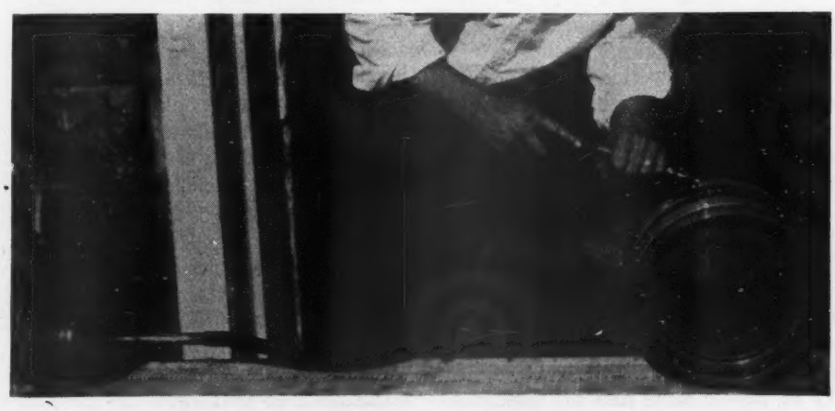
Our experience with these cutters has been very satisfactory, and we have found that under ordinary conditions the life of a cutter $\frac{3}{16}$ in. in diameter is between 85 and 95 linear feet. The length of the shank of this cutter is sufficient to permit a good clearance of the chuck even on large commutators.

The efficiency of the device is shown by the fact that the time required to undercut by hand a commutator 9¾ in. long containing 241 bars, with the mica flush, was 12 hr. and 12 min., whereas another commutator of the same size and identical in every respect was undercut by this outfit in 1¼ hr.

This outfit has the further advantage that it can easily be transferred from one place to another, as it is very light in weight. Also, it can be used as a portable grinder or drill while, owing to its construction, holes can be drilled in locations that would be very difficult to reach with most portable drills.

Cleveland, Ohio. ROYCE L. GRIMES.

This mica undercutting device consists of a ⅛-hp. motor which drives a flexible shaft on the outer end of which is a 3-jaw drill chuck that holds a dental milling cutter.



Growth of Industrial Centers

(*Continued from page 11*)

These industries are the lumber industry, steel works and rolling mills, paper and pulp wood, cotton goods, blast furnaces, foundries and machine shops. The primary horsepower reported for these six industries combined amounted to 13,934,074 hp. or 47.2 per cent of the total of all industries. These same six industries report the primary electrical horsepower owned or purchased as 6,329,908 hp. Thus about 45 per cent of these industries were electrified. Of these, however, foundries and machine shops were about 95 per cent electrified. Iron and steel works, including rolling mills, were a little over 61 per cent electrified, although blast furnaces were only 15 per cent electrified. The lumber and timber products industry and the paper and wood pulp industry showed a very low percentage of electrification. The printing and publishing and rubber tires and rubber goods industries, although they do not rank among the largest industries, show a relatively high percentage of electrification.

The total primary horsepower of the 237,854 establishments in the United States reported as using power was 29,504,792 hp.; of this 16,317,277 hp. was reported as electrical, or 54.5 per cent of the total. This shows that the six largest power-using industries were, as a group, below the average for all industry. These six, however, contained the industries which show the maximum and minimum percentage of electrification for all important industries.

The total primary horsepower of all industry was first reported in the census of 1879; this was 3,410,837 hp. The percentages of gain for each ten-year census report up to 1919 were: 74.1 per cent, 70 per cent, 84.9 per cent and 58 per cent respectively. The primary electrical horsepower was not reported until 1889; it then stood at 15,569 hp. The totals reported for each succeeding five-year period were: 1899, 492,936 hp.; 1904, 1,592,475 hp.; 1909, 4,817,140 hp.; 1914, 8,835,970 hp.; 1919, 16,317,277 hp. All of these figures were taken from United States Census reports.

The development of better methods of generation and the availability of power have had an important part in the industrial growth of the United States in the past. Further improvements in methods of application and utilization will have a corresponding influence on future industrial development.

Three Large Manufacturing Units

(*Continued from page 5*)

couplings and automotive equipment.

In 1901, the Allis-Chalmers Manufacturing Company was organized by combining Fraser and Chalmers, E. P. Allis Company, and Gates Iron Works, which had been for some years leaders in the middlewest in supplying engines, pumps and other heavy machinery to meet the demands of industrial and mining developments of the central and western sections of the United States. It was natural to add electric generators to connect to the line of engines and the hydraulic equipment and also motors devised to drive the special machinery as electric drives became more in demand, thus enabling the company to supply complete equipment and drives for entire plants or mills under one contract.

Some of the lines in which this organization has specialized in the production of equipment for specific industrial needs are: Cement mills, crushing, mining and metallurgical plants, saw mills and heavy woodworking plants, flour mills, hoisting equipment, hydraulic and pumping units, air compressors, gas, oil and steam engines, power transmission machinery, steam and water turbines and electric generators and drives for special service conditions, found in connection with these industries.

Most of this heavy equipment is made at the main plant at West Allis, a suburb of Milwaukee, Wis. In addition, a large factory is maintained at East Norwood, a suburb of Cincinnati, Ohio, for the manufacture of smaller electrical machinery for the generation, conversion, transformation and utilization of electric power. About 6,200 employes are engaged at the two plants which occupy a ground area of approximately 172 acres with a floor area of 3,645,875 sq. ft. A total of 190 electric cranes are used in the two plants and 21 miles of railway track in and around the two plants facilitate the handling of the heavy machine parts manufactured therein.

Use of Industrial Partitions

(*Continued from page 26*)

out of shape this may interfere more seriously with the re-erection.

Another use of industrial partitions is to separate off the lavatories and wash rooms. In most cases it is necessary to totally enclose these from the remainder of the plant. Ordinary steel, however, cannot be used to advantage around toilets and showers because of the difficulty of coating it so as to prevent rusting because of dampness. There are some special alloy metals used which overcome this. One of these is a special copper-steel alloy; another is an aluminum alloy. Both of these are rust resisting and do not depend upon paint or other coatings to prevent oxidation.

In planning for any installation it is well to consider how essential is appearance. If the partitions are to be used largely for offices, a better appearing unit would be more desired than would be necessary if it were used merely for factory stockroom or similar work. The appearance desired or considered necessary will no doubt have its effect on the price.

In planning an installation, the industrial man must first take into account the same points which he uses in getting an estimate from the manufacturer. These will also help him to get a better understanding of what would be expected of him. These factors which are required in an estimate as given by one manufacturer are listed in the table on page 26 and are practically self-explanatory so are not discussed further here. In any case it is usually best to adopt one manufacturer's equipment as standard, if possible.

EDITOR'S NOTE: Acknowledgment is made to the following companies for assistance in furnishing information and photographs for this article: Audubon Wire Cloth Co., Inc., Audubon, N. J.; The E. F. Hauserman Co., Cleveland, Ohio; David Lupton's Sons Co., Philadelphia, Pa.; Lyon Metallic Mfg. Co., Aurora, Ill.; The Mills Co., Cleveland, Ohio; The Sanymetal Products Co., Cleveland, Ohio; Van Dorn Iron Works, Cleveland, Ohio; Henry Weiss Mfg. Co., Atchison, Kan.

In giving credit to the manufacturers who had co-operated in furnishing information and photographs for the article on, "Shelves and Racks in Industrial Storerooms," which appeared in the December, 1924, issue of INDUSTRIAL ENGINEER, the name of David Lupton's Sons Company, Philadelphia, Pa., was inadvertently omitted.

Windings Having One Coil Per Slot

(*Continued from page 22*)

Fig. 7 shows an involute type of one-coil-per-slot winding. The name comes from the V-shape or involute character of the coil ends. Another illustration of the involute winding is shown in Fig. 8. The principal advantage of this winding is that all coils are of the same size and shape and that they require a comparatively small space for the coil ends. This type has the disadvantage, however, that due to the large number of relatively sharp bends, the coils are difficult to insulate and assemble in the armature.

Figure 9 shows an involute winding used on a three-phase rotor for an induction motor. This rotor has 180 slots with 90 coils forming ten poles. There are $(10 \times 3) \div 2 = 15$ dupole-phase groups having six coils each. Inspection of Fig. 9 will show that one side of a coil is longer than the other. In the group of six coils, the six long coil sides form one pole while the six short sides form another pole.

All of the windings that we have considered have been lap-wound, single-layer, half-coiled or consequent-pole windings, having only one coil per slot. In an early issue, we will take up one-coil-per-slot windings such as are used in turbo-generators and one-bar-per-slot windings as used in large motors carrying heavy currents.

Trade Literature *You Should Know About*

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Link-Belt Company, 300 West Pershing Road, Chicago, Ill.—Book 580, entitled "Link-Belt Electric Hoists and Overhead Traveling Cranes" illustrates the construction and operation of the various types of Link-Belt equipment and gives dimensions of the various capacities and types.

The Truscon Laboratories, Detroit, Mich.—A 33-page booklet illustrated with 19 photographs and sketches and entitled, "Science and Practice of Integral Waterproofing," tells in a simple and popular manner why concrete is porous and how it absorbs moisture, and explains the action of the various Truscon repellant waterproofing compounds.

The Automatic Reclosing Circuit Breaker Company, Columbus, Ohio.—Bulletin 314 describes the various automatic reclosing circuit breakers of the switchboard type, and auxiliary relays for the protection of direct-current circuits. A complete description, including dimensions and specifications with illustrations, is given for each of the various types.

Spaulding Fibre Company, Tonawanda, N. Y.—A 48-page booklet describes the numerous fibre products produced by this company, including Spaulding Bakelite-Duresto which may be supplied in sheets, tubes or rods for electrical purposes.

The American Transformer Company, Newark, N. J.—Bulletin 1030 describes several different types of industrial transformers for special purposes, such as 50,000-volt testing transformers, transformers for resistance heating, brazing and welding machines, furnace transformers, rivet-heating transformers, reactance coils, and ozone transformers.

W. A. Jones Foundry and Machine Company, 4401-51 West Roosevelt Road, Chicago, Ill.—Catalog 31 entitled, "Jones Power Transmission Machinery," covers shafthangers, pillow-blocks, couplings, collars, belt tighteners and similar items. Catalog 32 entitled "Jones Sprocket Wheels and Chain Belting" covers a full line of sprocket wheels and chain belting as well as chain tighteners, elevator boots, buckets, head wheels and similar equipment. Both catalogs are well illustrated, and list prices, tabulate dimensions and give complete specifications on all items.

Roeper Crane and Hoist Works, Inc., 1720 North Tenth St., Reading, Pa.—Form 112 describes the Roeper (formerly Reading) electric, Type R hoist with spur gear and worm drive; the capacity is from 500 to 4,000 lb. These hoists are single-speed, cord-controlled.

Black and Decker Manufacturing Company, Towson, Md.—Recent literature describes a new Black & Decker No. 3 reversible socket wrench and also the No. 2 electric tapper. Announcement is also made of a special 6-in. drill grinder.

General Electric Company, Schenectady, N. Y.—A 12-page booklet, Y-2019, describes the new Type A, welding electrode, gives details of the construction and characteristics and instructions for its use. Numerous tests on welding cast-iron specimens and on deposited metal specimens are described.

Pittsburgh Transformer Company, Pittsburgh, Pa.—Bulletin 2035, describes the construction and other features of Pittsburgh single-phase and polyphase power transformers.

Alexander Brothers, 14 South Street, Philadelphia, Pa.—A folder describes "Tentacular" suction belt which consists of oak-tanned leather belting to the underside of which are attached narrow, longitudinal strips, specially made of soft and spongy chrome-tanned leather. These are held in position by means of hollow rivets. It is claimed that the depressions or hemispherical pockets in the strip, having the inside of the hollow rivet as a body, act as suckers during use and cause adhesion of the belt on the pulley. This booklet describes other advantages obtained from the belting, the amount of power transmitted and gives formulas and other data for computing the belting required.

The Bryant Electric Company, 1421 State Street, Bridgeport, Conn.—A 202-page catalog entitled "Superior Wiring Devices" covers the complete line of Bryant supplies.

Renovatol Company, Mascher and Turner Streets, Philadelphia, Pa.—A circular describes "Renovatol" which is used to remove oil, grease or water from leather or canvas belts while operating at full load, and without removing the belt from the pulley.

Chas. A. Schieren Company, 30-38 Ferry Street, New York, N. Y.—A folder describes Duxbak leather belting, shows an unusual installation and also gives list prices.

Hasler-Tel Company, 461 Eighth Avenue, New York, N. Y.—A folder describes the Hasler speed indicator which can be used to find the revolutions per minute or surface speed in feet per minute directly and without calculation, as is ordinarily necessary when a watch is used.

The Esterline-Angus Company, Indianapolis, Ind.—Bulletin 1024 entitled "Graphic Instruments in the Pulp and Paper Industry" shows some of the numerous advantages and applications of such equipment in this industry.

The Hullhorst Micro Tool Company, Toledo, Ohio.—A folder describes the Hullhorst mica undercutting machine, in both portable and lathe types for industrial plants and its No. 10 size, for manufacturers of armatures and commutators. Special attention is given to the disc-type mica cutters which are made ¼ in. or $\frac{5}{32}$ in. in diameter and in various thicknesses.

Foote Bros. Gear and Machine Company, 236-246 North Curtis Street, Chicago, Ill.—Catalog 25, entitled "Foote IXL Speed Reducers," is a 79-page book, which contains a complete description of the construction of the different types of spur- and worm-gear speed reducers and shows the type of reduction to which each is best adapted. Bedplate castings for mounting speed reducers and motors and several types of flexible couplings are also described, listed and priced. A large variety of installation are illustrated.

J. Struthers Dunn, 1109 Race Street, Philadelphia, Pa.—A leaflet describes a new style of relay and resistance designed for pressure and temperature control and so arranged that contact is made but never broken on the primary contact. These relays are designed for all voltages from 6 to 220 volts and will carry and break 20 amp. with a magnet coil that takes from 8 to 10 watts.

The Sterling Varnish Company, Pittsburgh, Pa.—A reprint of a series of five articles on "Insulating Varnishes" which were published in INDUSTRIAL ENGINEER during 1924, has been prepared in pamphlet form and is ready for distribution. These articles were designed to appeal to the average shopman and describe in a practical, non-technical manner the best ways of applying insulating varnishes to obtain given results.

Revolvator Company, 336-352 Garfield Avenue, Jersey City, N. J.—A circular entitled, "How to Pile," illustrates and describes the advantages of piling boxes, cases, barrels, hogsheads, bales, crates, as well as bundles and packages, by special equipment designed for that purpose.

Crouse-Hinds Company, Syracuse, N. Y. —Folder 20 describes a line of safety switch condulets, tumbler type.

Pyott Foundry Company, 328 North Sangamon Street, Chicago, Ill.—A folder describes the line of Pyott hangers, bearings and hanger boxes and "red face" cast-iron pulleys and flywheels.

Standard Conveyor Company, North St. Paul, Minn.—Catalog 2 entitled "Wherever Conveying Is Done," illustrates a wide variety of Standard applications of conveying equipment in a number of industries.

Gifford-Wood Company, Hudson, N. Y. —Bulletin 24-A describes the construction and use of the portable flight conveyor for loading or elevating loose material. This may be driven by either motor or gasoline engine.

General Electric Company, Schenectady, N. Y.—Leaflet 67735-1 describes automatic switching equipment for sectionalizing and reclosing service on 275 volt d.c. mining and industrial service. This equipment eliminates general shut-downs caused by overloads as, in case of trouble, only the affected section is disconnected. As soon as the cause of trouble has been removed that section may be restored to service.

Weston Electrical Instrument Company, Newark, N. J.—A 100-page booklet entitled, "Electrical Testing in Industry" covers in a thorough way the use of testing equipment and the necessity, advantages and results which might be expected from making tests. This booklet was written by E. S. Lincoln, consulting electrical engineer, and discusses the subject purely from a practical operating standpoint. Numerous diagrams and methods of connection are illustrated as well as practical suggestions on overcoming the many difficulties which come up in conducting a test.

Norton Company, Worcester, Mass.—A monthly circular entitled "Norton Floors" describes numerous Norton installations. These floors are built especially to resist wear by using Alundum aggregate embedded in the concrete to a depth of approximately 1¼ in.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Circular 1705, entitled, "CL Carbon Circuit Breakers for Industrial Applications," describes equipment designed for use on 250-volt industrial systems and gives several new features in breaker design which have been incorporated in this new protective device.

Wagner Electric Corporation, St. Louis, Mo.—Bulletin 134 describes the Fynn-Weichsel motor, shows its construction and explains how it is able to correct power factor.

Condit Electrical Manufacturing Company, South Boston, Mass.—Industrial handbook 5005 covers a line of Condit safety air circuit breakers, oil switches, oil motor-starters, service switches and includes several handy tables as well as Underwriters' motor rules. This book also contains a description of the new Type N-4, manually-operated, oil motor-starter. This has overload protection, but is non-automatic.

Monitor Controller Company, Baltimore, Md.—Bulletin 106 describes the Monitor thermaload starter for small alternating-current motors. This is made in the automatic type, which may be arranged to permit control of the motor from a number of points, and also in a manually-reset type by which a motor may be stopped from a number of positions but started only from certain stations. Complete instructions for operation are included in addition to the description of the apparatus.

Chandler Machine Company, Ayer, Mass.—A booklet entitled, "Why Not Deposit a Part of Your Power Bill?" describes the construction, installation, lubrication and application of Chandler roller bearings for lineshafts and countershafts.

Lyon Metallic Manufacturing Company, Aurora, Ill.—Bulletin 209-B is a handbook of types and installation details for steel lockers. Considerable attention is paid to construction details and specifications of the various types. A large number of illustrations show how these may be used. Bulletin 104-A shows the various types of steel shelving, how they are constructed when shipped knocked-down and a number of the various combinations of shelving and drawer space which may be constructed from them. Bulletin 107 shows the commercial type of Lyon steel shelving.

Benjamin Electric Manufacturing Company, 847 West Jackson Boulevard, Chicago, Ill.—Bulletin 52 entitled, "Benjamin Industrial Lighting Equipment," in addition to describing and listing as well as pricing the various industrial and outdoor lighting equipment and devices, devotes several pages to lighting data and general information of interest to those who may be planning a lighting installation. Particular attention is called to the "Ben-ox" interchangeable devices, such as ceiling units, sockets, connectors, shade holders and reflectors for commercial and industrial lighting units which permit the quick removal of units for cleaning or for changing.

Sundh Electric Company, Inc., 5 Avenue C, Newark, N. J.—Bulletin 18 entitled, "Sundh Electric Control for Tire Pumps," describes the manual, automatic and combined types of control. This booklet also gives the regulations of the National Board of Fire Underwriters and the amendments adopted by the National Fire Protection Association.

The Foxboro Company, Inc., Foxboro, Mass.—Bulletin 96-1 describes the various indicating and recording pressure and other gages manufactured. A special bulletin illustrates the operation of the helical tube movement for controlling the recording device.

E. H. Freeman Electric Company, Trenton, N. J.—Catalog 8 includes a complete line of wiring devices, such as sockets, receptacles, rosettes, panel switches, plug and fuse cut-outs and other devices. Special charts of the interchangeable porcelain and glass shell line of sockets show the special bodies, caps and bases and gives a combination number for each of the various combinations.

Palmer Electric and Manufacturing Company, 175 Fifth Street, Cambridge, Mass.—Bulletin M-57 describes the universal service and industrial safety switch which receives the Underwriters' Classification AA. This has a special fuse cover which may be opened for changing fuses only when the switch is "off."

Ward Leonard Electric Company, Mount Vernon, New York.—Bulletin 57-revised describes and gives prices for the Vitrohm fractional horsepower armature speed controllers with an embedded resistor of fully enclosed type or of exposed contact type. Bulletin 58 describes the fractional horsepower starter with no-voltage protection for direct current motors. These are made for 115- and 230-volt motors rated from 1/50 to ½ hp.

American Blower Company, Detroit, Mich.—Bulletin 1613 describes the Ventura disc fans of standard stock sizes and types, gives their constructional features and application. These are pulley or motor-driven. Bulletin 1002 gives the standard stock sizes and type of Sirocco fans and utility blowers.

G. & W. Electric Specialty Company, Inc., 7440 South Chicago Avenue, Chicago, Ill.—A special folder describes the Types F and M underground distribution boxes for voltages up to 600 and the Type C box for voltages up to 15,000. These underground boxes are of standard construction. All boxes are given a 5-lb. air test which shows them waterproof.

Crouse-Hinds Company, Syracuse, N. Y. —Bulletin 2055 illustrates, describes and gives prices on the various types of Arktite circuit-breaking plugs and receptacles. In these the arc formed by pulling the plug is completely confined in a chamber of insulating material and it is impossible to form a short circuit or ground.

Albert and J. M. Anderson Manufacturing Company, 289 Eighth Street, Boston, Mass.—A bulletin describes the bus-bar or flat metal bender which is made in three sizes to take flat stock from ⅛-in. to ⅜-in. thick and up to 10 in. wide. This bender is held in a vise and will bend up to an angle of 90 deg.

Allen-Bradley Company, 491 Clinton Street, Milwaukee, Wis.—Bulletin 600 shows by charts the operation and various advantages claimed for the alternating current resistance starter.

Chandeysson Electric Company, St. Louis, Mo.—A group of bulletins describes the direct current motors and slip ring and squirrel cage alternating current motors of 1 to 100 hp., motor generator sets of 1 to 75 k.w. and electro-plating generators and motor-generator sets from 25 to 15,000 amp.